Volume 24 OCTOBER, 1949 NUMBER 1

IOWA STATE COLLEGE JOURNAL OF SCIENCE

A Quarterly of Research

CONTENTS

PUBLISHED BY
THE IOWA STATE COLLEGE PRESS
PRESS BUILDING
AMES, IOWA

IOWA STATE COLLEGE

JOURNAL OF SCIENCE

Published on the first day of October, January, April, and July

---

All manuscripts submitted should be addressed to W. H. Bragonier, Botany Hall, Iowa State College, Ames, Iowa.

All remittances should be addressed to The Iowa State College Press, Press Building, Ames, Iowa.

Single Copies: $1.25 (Except Vol. XVII, No. 4—$2.00). Annual Subscription: $4.00; in Canada $4.25; Foreign $4.50.

Entered as second-class matter January 16, 1935, at the post office at Ames, Iowa, under the act of March 3, 1879.

ABSTRACTS OF DOCTORAL THESES[1]

CONTENTS

[1] Complete copies of these theses may be consulted at the Library, Iowa State College, Ames, Iowa.

IOWA STATE COLLEGE

JOURNAL OF SCIENCE

Published on the first day of October, January, April, and July

---

All manuscripts submitted should be addressed to W. H. Bragonier, Botany Hall, Iowa State College, Ames, Iowa.

All remittances should be addressed to The Iowa State College Press, Press Building, Ames, Iowa.

Single Copies: $1.25 (Except Vol. XVII, No. 4—$2.00). Annual Subscription: $4.00; in Canada $4.25; Foreign $4.50.

Entered as second-class matter January 16, 1935, at the post office at Ames, Iowa, under the act of March 3, 1879.

ABSTRACTS OF DOCTORAL THESES [1]

CONTENTS

[1] Complete copies of these theses may be consulted at the Library, Iowa State College, Ames, Iowa.

ESTIMATION OF SOIL PRODUCTIVITY IN RELATION TO LAND VALUES AND FARM MANAGEMENT[1]

ANDREW R. AANDAHL

From the Department of Agricultural Economics
Iowa State College

During the years 1936 to 1942 inclusive, more than 2,000 sample corn yields were harvested from four different soil series in Iowa. Major emphasis was placed on differences within soil types caused by variations of slope gradient and topsoil depth. This study had two major objectives. One was to obtain some data of the productivity of some different soil types, and the other was to evaluate the sampling technique as a method of obtaining soil productivity data. These data were analyzed within a general analysis of the field of soil productivity research and its relationship to some economic problems.

The yield and quality of a specific plant or crop produced on any tract of land is the result of the combined influences of many factors—the properties of the soil being only one. The climate, the kind of plant, other plants or crops grown, and soil treatments applied are a few of these. They can be grouped conveniently into uncontrolled factors or natural environment, and controlled or management factors. Any estimate, measurement, or study of soil productivity has meaning only if all the other factors are considered.

The major objective of soil productivity research is to study past and present crop yields obtained on farms under different systems of soil management and to use these data for predicting future averages. In addition, there are several other important objectives. The rate of change of crop yields, both up and down, following major shifts in the system of soil management practiced, the nature of the crop yield range within a soil classification unit, and year to year variability are a few others. Also, considerable climatic range may exist within the geographic area of a soil type and it may be sufficiently great to affect yields of specific crops such as corn.

All methods of studying soil productivity involve yield measurements or estimates which may be either relative or absolute. Many general relationships between individual soil properties and crop yields are accepted. For example, assuming other properties similar, a dark colored soil is considered better for growing corn in the Middle West than a light colored one. Similarly, a silt loam is better than a loamy sand or a clay, and a granular structure better than a massive. All such relationships, however, have their origin from crop yield data. Their value is

[1] Doctoral thesis number 954, submitted June 1, 1949.

great but they must be used with discretion. The plant growth on any tract of land is the result of the combination of all the soil properties in its natural environment and under a definite system of management.

Some of the methods of studying soil productivity include general field observation, farmer memory interviews, and the use of Federal Census, annual farm census in some states, and data from experimental plots. These methods involve the use of presently available information. Unfortunately, estimates based on these sources lack accuracy. In order to obtain more precise data other methods must be used. Two methods used are the sampling procedure developed in Iowa and the farm record procedure used in Illinois. The first is designed to compare the productive abilities of soils intricately associated together in a soil pattern. It can also be used to compare soils and soil treatments on the same soils in different areas provided a detailed record of soil management is available. The farm record procedure is designed to measure the crop yields of soil types or soil association patterns which are relatively uniform over large areas such as fields or farms. The two methods are complementary and they add to the efficiency of each other.

During the analysis of the sample corn yield data, it soon became apparent that in this study the effects of slope gradient and topsoil depth could not be separated. Therefore, the analysis was directed toward obtaining the best relationship between yields and topsoil depth and to interpret the results as due to topsoil depth and all other causal factors correlated with depth. Differences in topsoil depth result from varying degrees of accelerated erosion, from variation in original topsoil, or from both. Slope characteristics are a major contributor to these variations. In order to obtain some estimates of their effects on the original topsoil, a virgin area was studied.

In the study of the virgin soil area, fifteen soil profiles were sampled and the nitrogen contents determined. Slope characteristics of each soil profile site including the general setting in the landscape, gradient, length, exposure, vertical curvature, and horizontal curvature were described. The lower nitrogen contents were associated with convex vertical curvature. A direct regression of nitrogen content on slope length measured from the slope shoulder was obtained. This study provided a better basis for the interpretation of the sample corn yield data.

The 2,176 corn yield samples collected in the study were harvested on different topsoil depths and slope gradients of Tama and Fayette soils in Allamakee and Tama Counties, Marshall soils in Audubon County, and Grundy soils in Lucas County. Two methods of analysis were used. One was the calculation of curvilinear regressions and the other involved intrafield comparisons. Considerable variations in the corn yield differences between topsoil depths were obtained. They ranged from none on Marshall silt loam under a high level of soil management to more than thirty bushels per acre between twelve and four inches on Fayette and Tama silt loams in Tama County. The higher yields were associated with the thicker topsoils. Because of the confounding of the causal factors,

no specific statements could be made about the effect of any one factor on corn yields.

Conditions which it is believed will make the use of the sampling method more efficient are as follows: The soil types or conditions to be studied should be specified and restricted. The sites should be located in the spring before the crops emerge in order to eliminate any bias. A continuous record of soil management data should be available for each field in the study. A large personnel should be available during the short harvest period. The statistical method of analysis should be determined for each problem to be studied before the data are collected.

Many economic aspects of soil productivity information exist. It is a basic requirement for the efficient use of the resources in agriculture. Equitable returns to labor, management, and capital can exist only if land values are consistent with economic land rent. Soil productivity is a major consideration of economic rent. Better landlord-tenant agreements can result from increased knowledge of the productive ability of soils. Relative land values reflect largely the influence of soil productivity.

THE FUNCTION OF CARBON DIOXIDE IN THE METABOLISM OF HETEROTROPHIC CELLS[1]

SAMUEL J. AJL

From the Department of Bacteriology
Iowa State College

Heterotrophic organisms completely deprived of carbon dioxide fail to multiply (1, 2). The phenomenon thus far has not been adequately explained. It may be postulated that the function of carbon dioxide is its participation in the formation of several essential metabolites. It may be hypothesized that failure to multiply in the absence of CO_2 results from the inability of these essential metabolites to be synthesized. If this hypothesis is correct, presence of the compounds should relieve the requirement of CO_2. The purpose of this study was, in part, to determine the validity of the above hypothesis.

A number of compounds have been found which substitute for CO_2 in the case of *Escherichia coli* and give not only normal but, in instances, enhanced growth. These compounds include the amino acids: arginine, proline, aspartic, and glutamic acids; the dicarboxylic acids: succinic, fumaric, malic, oxalacetic, and α-ketoglutaric acids; and one tricarboxylic acid: namely, *cis*-aconitic acid. Citric acid replaces carbon dioxide only in *Aerobacter aerogenes*. All of these compounds are constituents of the Krebs oxidation cycle, or their metabolic precursors. That this effect is not general is indicated by the failure of compounds such as alanine, lysine, pyruvic acid or citric acid, and histidine to be used by *E. coli* in the place of CO_2.

The results indicate that the degree of substitution of the various compounds is quantitatively significant.

Experimental data warrant the conclusion that the added compounds do not function by merely supplying CO_2 to the organism. If this were the case, the inclusion of CO_2 after maximum growth has been obtained in its absence should give a corresponding increase. This was found not to be the case. Also glucose which is a source of CO_2 is included in all media.

The compounds which replace CO_2 aerobically do so anaerobically as well. The C_5 compounds replace CO_2 to a greater extent than any of the other compounds, both in the presence and absence of oxygen. Oxalacetic acid is used very effectively under anaerobic conditions in place of CO_2. Thus it is indicated that this acid may be the chief substrate for amination or transamination under such conditions.

As a result of the effect of the C_5 acids, the suggestion is made that a C_5 compound may be formed in normal metabolism involving a C_4 and

[1] Doctoral thesis number 946, submitted May 11, 1949.

C_1 synthesis, and that this reaction may be of importance to the cell.

Reversibility of the following reaction has been demonstrated with a cell-free enzyme preparation of *E. coli*.

$$COOHCH_2CH_2COC^{13}OOH + O \rightleftarrows COOHCH_2CH_2COOH + C^{13}O_2$$

Adenosine triphosphate enhances the reversibility.

Occurrence of this reaction explains, in part, the function of α-ketoglutaric acid in replacing CO_2.

The components of the enzyme system include phosphate, adenosine triphosphate and magnesium. The last mentioned component can be fully replaced by manganese and only partially replaced by nickel ions. Evidence that the protein moiety has -SH groups has been obtained.

The mechanism by which the various compounds replace carbon dioxide has been investigated and the evidence thus far obtained points to an orderly manner in which this phenomenon takes place. The results show that the compounds replacing CO_2 must arise from one or two fixation reactions involving a C_3 and C_1 addition or a C_4 and C_1 addition in which the C_1 compound is carbon dioxide. The C_4 or the C_5 compounds thus formed are essential for the growth of heterotrophic bacteria. In the absence of the gas, the C_4 or C_5 compound must be supplied to the cells before growth occurs. The essential C_4 and C_5 compounds appear to be oxalacetic and α-ketoglutaric acids respectively.

Some work was done on the oxidation of succinic acid by cell-free enzyme systems. An increase in oxygen uptake was observed on the addition of biotin to a dialyzed cell-free extract of *E. coli* in the presence of α-ketoglutaric acid. This increase was appreciably lower when malonate was added. It is, therefore, likely that the biotin functioned in some step involving the oxidation of succinic acid. This has been found to be the case. On addition of biotin, activity of succinic dehydrogenase increases and in some instances up to three fold. Evidence has been obtained that succinic dehydrogenase is affected by biotin, and not the formation of a precursor or intermediate product of oxidation of the dicarboxylic acid.

LITERATURE CITED

1. Gladstone, G. P., P. Fildes, and G. M. Richardson
1935. Carbon dioxide as an essential factor in the growth of bacteria. Brit. Jour. Exp. Path. 16:335–48.

2. Valley, G., and L. F. Rettger
1927. The influence of carbon dioxide on bacteria. Jour. Bact. 14:101–37.

ECONOMIC ANALYSIS OF THE QUAD CITIES (IOWA-ILLINOIS) MILK MARKET[1]

EMANUEL LESTER BAUM

From the Department of Agricultural Economics
Iowa State College

1. FEDERAL REGULATION IN THE QUAD CITIES MARKET

The Quad Cities (Iowa-Illinois) milk market, like many other large markets, underwent an evolutionary process from a flat (single) price for all milk, and unchecked individual handler pools, to an intricate formula-pricing system legally enforced by the federal government. Federal regulation of the mechanics of pricing milk to producers was an emergency type of legislation designed to enhance the economic position of the milk producer.

The economic status of the milk producer improved since the institution of federal control in the Quad Cities marketing area in June, 1934. The direct effect of this type of public regulation has been obscured by the continual rise in the price level since 1934. Federal regulation has added stability in the market from the viewpoint of the milk producers. Producers were assured of minimum prices based on the ultimate use of the milk (classified-price plan) and formulas that met with their approval.

The producers' associations have emerged from an ineffective monopoly position in the sale of milk to distributors, to an effective monopolistic position, legalized by federal marketing license No. 58 and later federal marketing order No. 44.

Federal control has been in effect without the approval of milk distributors throughout this period. Milk distributors lost their monopolistic position in the purchase of milk from producers. To a large extent, distributors have maintained their price margins for milk, passing increased producer prices on to consumers. The larger distributors have benefited by this type of regulation, relative to the smaller distributors, with respect to the burden of handling milk used in the manufacture of by-products. This advantage was secured through the institution of a market-wide equalization pooling plan. Unfair trade practices were eliminated among distributors and between distributors and producers. All distributors in the market pay the same price for their milk, and all records are inspected and audited by the market administrator's staff.

Consumers have borne the major share of the price increases to producers. This important group has had little or nothing to do with

[1] Doctoral thesis number 944, submitted January 20, 1949.

policy formulation in the market. Consumers have not bothered to effectively organize resistance to producers' demands for more attractive pricing provisions contained in the marketing order.

2. PRICES AND PRICING PROVISIONS

The primary basis for payment to milk producers since June, 1934, has been the clasified-price plan. This type of pricing plan prices milk according to its ultimate use. Discriminative marketing practiced through the classified-price plan enables the producers to secure greater returns than under a flat-price system. Greater monopoly returns result from charging a higher price for milk sold for the use in which demand is relatively more inelastic.

The classified-price plan was incorporated with a market-wide equalization plan and a base-rating plan until December 30, 1947. At present, the classified-price plan is incorporated with a market-wide equalization and seasonal pricing plan. The market-wide equalization pooling plan treats all producers alike in that they receive a uniform price per hundredweight of milk. The seasonal pricing plan recognizes the higher cost of producing milk in the fall and winter months. Higher prices for milk during the high-cost production months are provided for in an attempt to even out milk production and relieve the present critical shortage of Grade A milk.

Prior to December 15, 1941, the Class 1 price was a negotiated and fixed price. Since that date, the Class 1 price has been tied to the Class 3 price and has varied with the Class 3 price. Prior to the above date, the Class 2 price was tied to the butter price formula, and was a fixed price for a short period of time. Since that date, the Class 2 price, like the Class 1 price, was tied to the Class 3 price. This change in the basis of pricing recognized the importance of the evaporated and condensed milk price created by World War II.

The Quad Cities milk marketing area operated under a licensing agreement from June, 1934, to January 30, 1940. The market has operated under a federal marketing order and agreement since that date. It appears that the marketing order will be retained and strengthened because of the price security afforded producers, and the stability that it has brought to the market.

3. THE SUPPLY SIDE OF THE MARKET

The Quad Cities milk marketing area lies in an agricultural area that predominantly features livestock production. About 97 per cent of the producers belong to either of the two cooperative associations, and these associations hold the leadership in determining pricing policy which in turn influences milk production in the supply area. The major portion of the milk is hauled to market by private truckers, who contract with cooperatives for this service. All producers pay a fixed hauling charge which is negotiated between the cooperatives and the truckers.

This milk market, like other major markets, experiences marked seasonal fluctuations in production. May is usually the highest milk production month and November is the lowest. The average November production amounts to 70 per cent of the highest production month. Seasonal pricing has been substituted for the base-rating plan as an incentive for securing a higher fall season milk production. The industry believed that seasonal pricing would be a more positive corrective to the seasonal production problem because it assures producers a higher price during the months of high cost production. The seasonal pricing scheme is superior to the base-rating plan in that it has incorporated the principle of forward pricing. The element of forward pricing indicates to the producer relative prices for his milk in advance of the production period.

The Quad Cities market has been considered to have a short supply of milk since November, 1946. At present, the producer representatives advocate successively higher prices until milk producers in the local supply area are induced to increase their milk production. When a market encourages nearby milk production in the local area where other alternatives present more remunerative returns, the industry acts to the detriment of the general public welfare. A more constructive method would be that the milk supply area be enlarged to the point where a cushion of 15–20 per cent surplus is insured in the short production months. This alternative accompanied by a strong seasonal pricing plan would help prevent a marked increase in flush season receipts. In the short run, a short supply would be made up by emergency shipments of milk from areas of surplus production.

4. THE DEMAND SIDE OF THE MARKET

Information on milk consumption in the Quad Cities is lacking in this market. More should be known about the character of consumption by income, age, size of family, season of the year, etc. We must know more about consumer reaction to price changes in order to guide future policy planning for the market. Proper pricing of milk encourages or maintains a high level of consumption. A strong demand for fluid milk and cream relative to total market receipts aids the industry in maintaining a stable market.

Total sales of Class 1 and Class 2 milk have steadily increased since 1934. The average of total daily sales during 1947 was about 141 per cent greater than the average daily sales during 1935. During this period of federal regulation, the population, economic activity, and per capita income increased steadily until 1940 and has increased more rapidly since that date. Class 1 sales have averaged about 50 per cent of the total milk utilized in the market from 1934 to 1947. Class 2 sales averaged about 14.5 per cent of the total milk utilized in the market from 1934 to 1947.

There is relatively little change in consumption of fluid milk from the low to the high consumption month. During the period 1935 to 1947,

1940 was the only year when consumption varied more than 14 per cent from the lowest to the highest months. The average variation for all years considered was 11.36 per cent.

It is estimated that the total population in the marketing area has increased 36 per cent from 1934 to 1948. Per capita consumption of fluid milk and fluid cream has increased 88 per cent during the period from 1934 to 1947. Consumption of fluid milk fluctuates less than the consumption of fluid cream. Fluid cream sales decreased during World War II because of War Food Administration controls.

5. ANALYSIS OF DISTRIBUTION

The seven largest distributors in the Quad Cities market control approximately 75 per cent of the milk distribution business. Fifty-three per cent of the firms studied were organized on a partnership basis. The majority of the milk distributors have been engaged in this type of business for more than twenty years.

The total capital investment per daily quart of milk equivalent amounted to $17.23 for the nineteen distributors studied. The capital turned over each 3.45 months. The average return on capital invested was $7,335 during the calendar year of 1947. This dollar return amounted to 15 per cent of the capital invested. There was no significant difference in capital efficiency between pasteurization firms in the different size groups.

The firms studied received an average return of 16.18 cents per quart of milk equivalent. Of this amount, the unit product cost was 9.05 cents, or 56 per cent of the average sale price. The distributors' operating margin amounted to 7.13 cents per quart of milk equivalent. Plant costs amounted to 2.41 cents per unit, or 15 per cent of the sale price. Selling and delivery costs amounted to 3.07 cents per unit, or about 19 per cent of the sale price. Administrative costs amounted to 0.57 cents per unit or about 4 per cent of the sale price. The net profit per quart of milk equivalent amounted to 0.71 cents, or 4 per cent of the total sale price. The total operating cost was 6.42 cents per quart of milk equivalent.

The group of largest firms received the highest net return per quart of milk equivalent; 0.16 cents per unit more than the 1,339 quart group and 0.56 cents more than the 680 quart group. The group of largest firms were more efficient in plant operation than other groups, but less efficient in selling and delivery.

The firms that had the largest proportion of wholesale sales operated on the smallest margin. Total operating cost was the smallest for the groups of firms whose wholesale business was the greatest. This group of firms averaged the highest net return per quart of milk equivalent. Also, this group of firms had a significantly lower selling and delivery cost.

Labor was the largest operational cost. The labor cost amounted to 55 per cent of the total distribution cost of the firms studied. Efficiency

in the use of labor must be stressed continually in seeking minimum operational costs.

The retail price of milk has been relatively stable compared to prices paid to producers. The retail price of a quart of milk in the Quad Cities follows the per quart producer price. Dealers' margins have been a relatively constant proportion of the total sales price throughout the period studied.

6. A POSITIVE MARKETING POLICY

A positive marketing policy for the Quad Cities must accomplish the following:

1. Effect greater efficiencies in the marketing system.
2. The elimination of inequities in the present pricing system.
3. The strengthening of the present pricing system by the addition of more flexible provisions that will aid in the maintenance of prices and income to milk producers in line with alternative outlets for milk and general economic conditions.
4. Elimination of the present shortages of market supplies and maintenance of receipts in balance with Class 1 sales.
5. Achieve greater recognition of milk distribution problems, by the inclusion of a stronger milk distributor representation in price policy determination.
6. Obtain more direct consultation with representatives of consumer groups, acknowledging their importance in the maintenance of market stability.

All future modifications of the present system would be constructive if they are sound and prepare the way towards a market policy that is flexible and treats all interested groups equally. In general, these modifications would prepare the foundation for a policy that would be strong enough to adequately take care of the future changes in conditions. Improvements in the present system of marketing fluid milk in the Quad Cities would incorporate long run rather than short run considerations as has been done in the past.

The presented program supplements the Federal Market Administration with a local Milk Industry Board. This Board would equally represent all interests, study market conditions through the medium of dependable data, and recommend policies for the industry. The industry and the market should choose a Board that will win the respect, faith, and admiration of all concerned.

The federal order probably would be strengthened by using seasonal and quality premiums that are a given percentage of the Class 3 price. This type of provision would add flexibility to the order, and possibly prevent unwanted surpluses in the future. Stability in the market and equitable treatment of all interested groups can be furthered by eliminating inequities in the handling of other source milk

and transfers of milk. Pricing provisions should insure that milk would be secured on the basis of comparative advantage and on the principle of least alternative costs.

Formula pricing provides a sound primary basis for flexibility in the pricing of fluid milk. The test of proper pricing is the absence of either marked shortages or surpluses other than normal seasonal changes in receipts. Another indicator is the change in seasonal receipts. The prices for Class 1 and Class 2 milk should be based upon manufactured prices, because the Quad Cities is close to these alternative outlets for milk; therefore, the blend price should be such that a proper balance is maintained because of the market demand for milk consumed in fluid form and total market receipts.

A consolidation of the cooperative associations' surplus plant facilities appears to be justified. There appears to be no justification for the present duplication of facilities, for the increased costs of maintaining partly idle facilities must be borne by the associations' patrons.

Lastly, there appears to be justification for recommending the centralization of all receiving facilities at the association's surplus plant. This change would not decrease the degree of competition in the sale of milk between the producer and distributor. The adoption of this plan would eliminate the costly operation of receiving milk, weighing and taking fat samples, and washing cans in each distributor's plant. It is felt that the savings effected would justify this change in the marketing system.

EXPLICIT SOLUTION OF CERTAIN SINGULAR INTEGRAL EQUATIONS[1]

HENRY DAVID BLOCK

From the Department of Mathematics
Iowa State College

First the explicit solutions to the following integral equations are found.

(1) $$f(x) = \lambda \int_0^\infty e^{-k|x-y|}\, g(y)\, dy$$

(2) $$g(x) = \lambda \int_0^\infty e^{-k|x-y|}\, g(y)\, dy$$

(3) $$f(x) = \lambda \int_{-\infty}^\infty e^{-k|x-y|}\, g(y)\, dy$$

(4) $$g(x) = \lambda \int_{-\infty}^\infty e^{-k|x-y|}\, g(y)\, dy$$

(5) $$f(x) = g(x) - \lambda \int_0^\infty e^{-k|x-y|}\, g(y)\, dy$$

(6) $$f(x) = g(x) - \lambda \int_{-\infty}^\infty e^{-k|x-y|}\, g(y)\, dy$$

(7) $$f(x) = \lambda \int_0^\infty |x-y| e^{-k|x-y|}\, g(y)\, dy$$

(8) $$g(x) = \lambda \int_0^\infty |x-y| e^{-k|x-y|}\, g(y)\, dy$$

(9) $$f(x) = g(x) - \lambda \int_0^\infty |x-y| e^{-k|x-y|}\, g(y)\, dy$$

(10) $$f(x) = \lambda \int_{-\infty}^\infty |x-y| e^{-k|x-y|}\, g(y)\, dy$$

(11) $$f(x) = g(x) - \lambda \int_{-\infty}^\infty |x-y| e^{-k|x-y|}\, g(y)\, dy$$

(12) $$g(x) = \lambda \int_{-\infty}^\infty |x-y| e^{-k|x-y|}\, g(y)\, dy$$

There is no generality lost by taking for the lower limit of the inte-

[1] Doctoral thesis number 955, submitted June 2, 1949.

gral only the two cases 0 and $-\infty$. The method employed here is due to Thielman[2], who used it to solve (1) and (2). The following is a typical result.

Theorem. Necessary and sufficient conditions that $g(x)$ be a solution of equation (7), $x \geqq 0$, $k > 0$, $\lambda \neq 0$, $f(x) \varepsilon C^3$, εC^4 in sections, $f''''(x) = O(e^{cx})$, $c < k$, $x \to \infty$, are:

$$(a) \qquad g(x) = \frac{1}{2\lambda} \{ 2k^2 f(0+) \sin kx + 2k[2k f(0+) - f'(0+)] \cos kx + f''(x) - 3k^2 f(x) + 4k^3 \int_0^x \sin k(x-t) f(t)\, dt \},$$

(b) the integral in (7) exist.

For the homogenous equations the characterictic values of λ are shown to form a continuous spectrum. For the kernel $e^{-k|x-y|}$ the regions are: $\lambda > \frac{k}{2}$, $\lambda = \frac{k}{2}$, $0 < \lambda > \frac{k}{2}$. For the kernel $|x-y| e^{-k|x-y|}$ the regions are: $\lambda > \frac{k^2}{2}$, $\lambda = \frac{k^2}{2}$, $0 < \lambda < \frac{k^2}{2}$, $-4k^2 < \lambda < 0$, $\lambda = -4k^2$, $\lambda < -4k^2$. The associated characteristic functions change as we pass from one region into another. We note that although the existence of a solution for (1) requires that $f'(0) = kf(0)$, the existence of a solution for (7) does not depend on the end point properties of $f(x)$.

We now introduce the family of integral transformations, on a suitable function $g(y)$, defined by

$$(13) \qquad f_n(x,k) = \int_{-\infty}^{\infty} |x-y|^n e^{-k|x-y|} g(y)\, dy = L_n\{g(y)\}, \; k > 0, \; n = 0,1,2,\ldots .$$

Since $f_n(x+a,k) = L_n\{g(y+a)\}$, it follows that $L_n\{g(y)\} = D_x L_n\{g(y)\}$, when $g(y) \varepsilon C$, $\varepsilon C'$ in sections. Corresponding formulas are given when $g(y)$ and its derivatives have finite jumps. We derive the formula

$$(14) \qquad L_m\left\{L_n\{g(y)\}\right\} = L_n\left\{L_m\{g(y)\}\right\} = \sum_{i=0}^{n} \binom{n}{i} \frac{(m+i)!}{(2k)^{m+i+1}} L_{n+i} + \sum_{j=0}^{m} \binom{m}{j} \frac{(n+j)!}{(2k)^{n+j+1}} L_{m+j} + \frac{m!n!}{(m+n+1)!} L_{m+n+1}.$$

From this it follows that L_n can be written as a linear combination of the iterates of L_0. When we regard (13) as an integral equation in which $g(y)$ may involve the parameter k, this result shows that all the characteristic functions of L_0, are also characteristic functions of L_n, but

[2] H. P. Thielman, On a class of singular integral equations occurring in physics. Quarterly of Applied Mathematics, 6:443-48. (1949).

associated with different eigenvalues. Thus, if $L_n = \sum a_i L_o^i$ and $L_o\{\phi(y)\} = \frac{1}{\lambda_o}\cdot\phi(y)$ then $L_n\{\phi(y)\} = \frac{1}{\lambda_n}\phi(y)$, where $\frac{1}{\lambda_n} = \sum_i \frac{a_i}{\lambda_o^i}$. In particular, $\lambda_1 = \frac{k\lambda_o^2}{k-\lambda_o}$. This mapping of the entire spectrum of L_o onto the spectrum of L_1 is exhibited explicitly using the previous results, and it is seen that the converse does not hold. The inversion formula

$$\operatorname*{Lim}_{k\to\infty} \frac{k^{n+1}}{n!} L_n\{g(y)\} = g(x+) + g(x-),$$

when $g(y)$ does not involve k, is derived. This shows the uniqueness of the inverse transform and also the restrictions on the class of transform functions. It also gives the condition that a solution to the integral equation (13) be independent of k. Formula (14) also offers an easy computational procedure to find the iterates of L_o and L_1, whose kernels are the iterated kernels of (3) and (10). Other properties of the transformation are also studied and an illustration given of its application to a special functional equation.

Examples, illustrating the use of the results, are introduced into the text as the theory is developed. An appendix, consisting of a table of those definite integrals used in the text which are not in the standard tables is also given.

REMOVAL OF GLUCOSE FROM EGG ALBUMEN BY A CONTROLLED FERMENTATION[1]

CAROL HOUCK BOLLENBACK

From the Department of Food Technology
Iowa State College

The usual commercial procedure for the preparation of dried egg albumen consists of fermenting liquid albumen free of sugar, removing the mucin scum, then drying on trays. A minor fraction is spray dried and foam dried. It seems possible that the methods employed for fermentation and drying render the final product unsuitable for angel cakes. Evidence suggestive of this possibility is to be found in various publications and in the unpublished work done in the Poultry Products Laboratory at the Iowa State College. The primary objective of the present work was to develop a fermented egg white which, after drying, could be reconstituted and made into an angel cake comparable to that obtained from fresh white.

A study was made of methods for fermenting albumen for the purpose of removing glucose without impairing angel cake making properties. After a preliminary survey of a number of organisms, *Aerobacter aerogenes* (N.R.R.L. #199) was selected for further study. Conditions were determined for rapidly removing glucose which would allow the mucin to remain in the dispersed form.

Varying the surface/volume ratio had no appreciable effect on the time required for the removal of glucose; nor did adjustment of the *p*H to neutral or acid levels affect the time favorably. Addition of 0.1 per cent yeast extract reduced the fermentation time by approximately half. By adjusting the temperature and size of inoculum it was possible to vary the time required for glucose removal from five to thirty-two hours; thus, the time of fermentation can be regulated to the convenience of almost any contingency.

An adaptation of the two hour browning test for determining the presence of glucose in egg white was developed during the course of this study. One-tenth ml. of egg white was placed on half of a preheated petri plate and heated under a General Electric reflector-drying lamp for fifteen minutes. Under carefully standardized conditions it was possible to detect the presence of glucose by the appearance of a yellow to brown color at the end of the fifteen minute period.

Serial passages of *Aerobacter aerogenes* (N.R.R.L. #199) were made in egg white containing 0.1 per cent yeast extract, without benefit of aseptic techniques. After 160 passages the culture was still pure.

[1] Doctoral thesis number 961, submitted June 7, 1949.

Adjustments in *p*H, both during and after fermentation, were also made and the effects studied. Agitation and/or addition of dilute NaOH were used in an effort to control *p*H during fermentations. These treatments caused an accumulation of mucin on the stirrer and resulted in a dried product of inferior whipping quality. However, when fermented albumen was adjusted to *p*H 9.0 with NH_4OH just prior to drying, a dried product of improved whipping quality resulted.

Blending the egg white into a homogeneous liquid was essential to keep the mucin in a dispersed form at the lower *p*H levels reached during fermentation.

Angel cakes prepared from fermented egg white gave results significantly different from fresh liquid when a regular formula was used. However, when the amount of cream of tartar was reduced or omitted from the formula, the cakes prepared from the fermented albumen were not significantly different from those prepared from the fresh liquid.

ACTION OF *ACETOBACTER SUBOXYDANS* UPON SOME 1-DESOXY SUGAR ALCOHOLS[1]

GEORGE NORRIS BOLLENBACK, JR.

From the Department of Chemistry
Iowa State College

Certain species of the genus *Acetobacter* can, by selective oxidation, produce chemically pure organic compounds in excellent yields. Historically, the foremost of these species is *A. xylinum;* more recently, *A. suboxydans* has assumed a highly important position. The specific action of *A. xylinum* is elucidated in what has become known as "Bertrand's rule." In effect, this rule states that for fully hydroxylated sugar alcohols of four or more carbon atoms *A. xylinum* will promote the oxidation of a secondary alcohol group to a ketone, but only if the hydroxyl group involved is adjacent to a primary hydroxyl group and in *cis* relation to an adjacent secondary hydroxyl group. *A. suboxydans* is more specific in that only members of a D- series with the proper configuration will be oxidized. The present work was undertaken to test the tenability of such a rule for *A. suboxydans* with relation to the action of the organism towards the 1-desoxy sugar alcohols.

Ten 1-desoxy sugar alcohols were prepared and subjected to the action of *A. suboxydans* in a medium consisting of 100 mg. of sugar alcohol and 50 mg. of yeast extract per 10 ml. The extent of oxidation was determined by analysis for the production of reducing compounds at five and ten day intervals.

Four new 1-desoxy alcohols were prepared: 1-desoxy-D-arabitol (D-lyxomethylitol), m.p. 131–132° C.; $[\alpha]_D^{29}$ +2.46° (H_2O) (l, 2; c, 1.01); tetraacetate, m.p. 115–116° C.; $[\alpha]_D^{30}$ +27.30° ($CHCl_3$) (l, 2; c, 1.00): 1-desoxy-L-arabitol (L-lyxomethylitol), m.p. 129–131° C.; $[\alpha]_D^{30}$ −1.46° (H_2O) (l, 2; c, 1.02); tetraacetate, m.p. 115°; $[\alpha]_D^{30}$ −26.37° ($CHCl_3$) (l, 2; c, 1.29): 1-desoxy-D-iditol (D-idomethylitol), sirup; $[\alpha]_D^{28}$ +1.43° (H_2O) (l, 2; c, 1.00); pentaacetate, m.p. 100° C.; $[\alpha]_D^{28}$ +10.5° ($CHCl_3$) (l, 2; c, 1.00): and 1-desoxy-L-glucitol (D-gulomethylitol), m.p. 130-132° C.; $[\alpha]_D^{28}$ −2.30° (H_2O) (l, 2; c, 1.01); 3,4:5,6-diacetone derivative, sirup; $[\alpha]_D^{28}$ −1.00° (MeOH) (l, 2; c, 1.00). The methods of preparation included the hydrogenolysis of the corresponding mercaptals with

[1] Doctoral thesis number 966, submitted June 4, 1949.

Raney nickel and the addition of methyl magnesium iodide to appropriate acyclic derivatives.

Of those 1-desoxy alcohols tested, the following gave highly conclusive exidence (production of at least 80 mg. of reducing compound per 100 mg. of alcohol) of having been oxidized by *A. suboxydans*: 1-desoxy-D-glucitol, 1-desoxy-D-mannitol, and 1-desoxy-D-arabitol. The production of reducing compounds from the 1-desoxy-L-glucitol, 1-desoxy-L-mannitol, 1-desoxy-D-iditol, and 1-desoxy-D-gulitol was insignificant. The 1-desoxy-D-galactitol, 1-desoxy-L-arabitol, and 1-desoxy-L-allitol gave definite but not high yields of reducing compounds.

The addition of varying amounts of sorbitol (25, 50, and 75 mg. per 10 ml. of medium) to media containing 1, 2, and 3 per cent of 1-desoxy-L-galactitol showed that over a period of ten days the amount of reducing compound produced from the 1-desoxy-D-galactitol by *A. suboxydans* could be increased. A maximum yield of 47 mg. of reducing compound per 100 mg. of alcohol was obtained by utilizing 0.025 mg. of sorbitol and 100 mg. of 1-desoxy-D-galactitol per 10 ml. of medium. The re-inoculation of media containing 0.025 mg. of sorbitol and 100 mg. of 1-desoxy-D-galactitol per 10 ml. of medium with additional bacteria and sorbitol at five and ten day periods gave a further increase (68 mg. per 100 mg. of alcohol) in analytical yield of reducing compound. Similarly, from the 1-desoxy-L-arabitol a maximum yield of 45 mg. of reducing compound per 100 mg. of alcohol was obtained, using reinoculation and sorbitol.

In no case was an attempt made to isolate the reducing compound produced and therefore the site of oxidation could not be defined. While insufficient evidence was collected to allow any generalization of the oxidative specificity of *A. suboxydans* towards the 1-desoxy sugar alcohols it can be safely stated that the empirical rule put forth above does not apply to this type of compound.

Several mercaptals were also tested and all yielded minor amounts of unidentified reducing compounds with no indication of configurational specificity.

The action of *A. suboxydans* upon a four carbon sugar alcohol, L-threitol, was also examined. No detectable amount of reducing compound was produced from this compound over a ten-day period.

REACTIONS OF ORGANOLITHIUM COMPOUNDS WITH SOME ORGANIC PHOSPHORUS AND NITROGEN COMPOUNDS [1]

GEORGE EARL BROWN

From the Department of Chemistry, Iowa State College

A literature review of the methods of preparation and the substitution reactions of the arylphosphorus compounds was made. The preparation and the substitution reactions of the arylamines were briefly reviewed. The metalation reaction of organolithium compounds was extended to the aromatic phosphines and amines.

A number of reactions, designed to test a mechanism (1) for the formation of tetraphenylphosphonium bromide by the oxidation and subsequent hydrolysis of a mixture of triphenylphosphine and phenylmagnesium bromide, was reported. The results supported the following reaction mechanism: The magnesium atom of the Grignard reagent exchanged one of the oxonium ether molecules for a triphenylphosphine molecule. By stirring this complex in the presence of oxygen, an oxygen atom entered the molecule at the magnesium-phosphorus bond. The phenyl group attached to the magnesium migrated, by a 1–3 shift, to the phosphorus, and the molecule split to form the $[C_6H_5)_4P]^+$ and the Br-Mg-O$^-$ ions. Hydrobromic acid neutralized the negative ion with the formation of tetraphenylphosphonium bromide.

Metalation of primary and secondary arylamines by *n*-butyllithium has been observed to take place in the position *ortho* to the nitrogen atom. In analogous reactions with triphenylamine and triphenylphosphine the substitution was shown to involve the position *meta* to the hetero element.

Some carboxydiphenylamines and carboxytriphenylamines were synthesized. The methyl esters of amino- and iodobenzoic acids were found to be superior reagents for these condensations.

All organometallic reactions were run in an atmosphere of dry nitrogen. The *n*-butyllithium solutions were prepared (2), filtered (3), and standardized (4) in the customary manner.

A mixture of *n*-butyllithium and triphenylphosphine was refluxed for forty-eight hours, then was carbonated with dry ice to give a 5.9 per cent yield of *m*-carboxyphenyldiphenylphosphine, m. p. 157°. Characterization of this acid was achieved by the following sequence of reactions: Diphenylcholorophosphine was treated with *m*-bromophenylmagnesium bromide to give *m*-bromophenyldiphenylphosphine, which was not isolated. The dry ether solution of *m*-bromophenyldiphenylphosphine was treated with *n*-butyllithium for thirty minutes before car-

[1] Doctoral thesis number 657, submitted December 9, 1941.

bonation with dry ice. The resulting acid melted at 157° and showed no melting point depression when mixed with the acid prepared above by hydrogen-metal interconversion. The melting point of a mixture of the *meta* and *para* acids was definitely depressed.

p-Bromophenyldichlorophosphine was refluxed with two equivalents of phenylmagnesium bromide for two hours. Hydrolysis in the customary manner gave *p*-bromophenyldiphenylphosphine, b. p. 205°–210°/4 mm. This compound, when treated with *n*-butyllithium and dry ice as above, gave a 57 per cent yield of *p*-carboxyphenyldiphenylphosphine, m. p. 156°.

m-Carboxyphenyldiphenylphosphine was treated with alkaline permanganate to give a 57 per cent yield of *m*-carboxyphenyldiphenylphosphine oxide, m. p. 232°.

Triphenylphosphine was treated with phenylmagnesium bromide in ether (1), phenyllithium in ether and phenylsodium in benzene. This was followed by oxidation to give 82.6, 31, and 0 per cent yields, respectively, of the dihydrate of tetraphenylphosphonium bromide. No tetraphenylphosphonium bromide was obtained when triphenylphosphine oxide was treated with phenylmagnesium bromide or phenyllithium in the customary manner. Triphenylphosphine also failed to give tetraphenylphosphonium bromide when treated with lithium phenoxide.

Treatment of triphenylphosphine with dry oxygen gas gave no triphenylphosphine oxide. Neutral permanganate oxidized triphenylphosphine to triphenylphosphine oxide in a 98.3 per cent yield.

Oxidation of phenyllithium with dry oxygen gas gave a 21 per cent yield of phenol.

Aniline was refluxed for fifty hours with an excess of *n*-butyllithium and was then carbonated with solid carbon dioxide to give a small amount of anthranilic acid (5).

Treatment of *o*-bromoaniline with an excess of *n*-butyllithium for forty minutes subsequent to carbonation gave a 35 per cent yield of anthranilic acid. *p*-Bromoaniline treated in an identical manner gave an oil that resisted all efforts to change it to the crystalline form.

A seven per cent yield of N,N-diphenyl-*m*-aminobenzoic acid (6), m. p. 186°, was obtained by refluxing an ether solution of triphenylamine with *n*-butyllithium for forty-eight hours prior to carbonation with crushed dry ice.

Methyl N,N-diphenyl-*m*-aminobenzoate (6), a light yellow viscous liquid, b. p. 205°/3 mm., was obtained in a 70.5 per cent yield by condensing (7) methyl *m*-iodobenzoate with diphenylamine. The methyl ester was hydrolyzed to give an acid that was shown to be identical with the product obtained by direct metalation of triphenylamine. The acid was decarboxylated with soda-lime to give a 94 per cent yield of triphenylamine.

No condensation was observed when diphenylamine was treated with *p*-iodobenzoic acid but a 66.5 per cent yield of methyl N,N-diphenyl-*p*-aminobenzoate (6), m. p. 89°, was obtained by condensing it with

methyl *p*-iodobenzoate. The ester was quantitatively hydrolyzed to N,N-diphenyl-*p*-aminobenzoic acid (6), m. p. 202°.

Iodobenzene reacted with methyl *p*-aminobenzoate to give methyl N-phenyl-*p*-aminobenzoate (6), m. p. 115°, which hydrolyzed to give N-phenyl-*p*-aminobenzoic acid, m. p. 156°.

Methyl N,N-diphenylanthranilate (6), m. p. 131°—132°, was prepared by treating N,N-diphenylanthranilic acid with an ether solution of diazomethane.

An ether solution of dibenzofuran was refluxed for four hours with one equivalent of *n*-butyllithium. The reaction mixture was added dropwise to an ether solution of iodine to give a 37.5 per cent yield of 4-iododibenzofuran, m. p. 70°–71°, b. p. 180°/3mm.

LITERATURE CITED

1. Dodonow and Medox
1928. Ber. 61, 907.

2. Gilman, Zoellner, and Selby
1933. Jour. Amer. Chem. Soc. 55, 1252.

3. ———, Langham, and Moore
1940. *Ibid* 62, 2327.

4. ———, Wilkinson, Fishel, and Meyers
1923. *Ibid* 45, 150.

5. ———, Brown, Webb, and Spatz
1940. *Ibid* 62, 977.

6. ———, and Brown
1940. *Ibid* 62, 3208.

7. Kawai
1928. Jour. Chem. Soc. Japan 49, 235 [C. A. 24, 80 (1930)].

RESOURCE ALLOCATION AND INCOME KENTUCKY TYPE-OF-FARMING AREA VII[1]

GEORGE BOYD BYERS[2]

From the Department of Agricultural Economics
Iowa State College

The purpose of this thesis is to examine the agricultural resources and determine the adjustments for optimum allocation of resources of Type-of-farming Area VII in Kentucky.

Data obtained from county offices of the Agricultural Adjustment Administration and topographic maps furnished the basis for setting up land use areas. Further detailed information was obtained by Farm Business Surveys upon a purposive random sample of farms representative of modal size groupings. Feed records, farm practices, and machinery use-cost relationships were obtained for selected farms for the area as a whole.

Over 25 per cent of the farms were operated by tenants. Over one-fourth of the approximately 20,000 people in the farm labor force of Area VII were wage workers. Tenant-operated farms were usually less productive than owner-operated farms. Soil improvement and maintenance of high-producing livestock were essential to optimum resource allocation. Tenure arrangement retarded application of soil treatments, maintenance of farm improvements, etc., because of the uncertainty of the tenant receiving compensation for unused improvements at the termination of the lease. Hence, in general, optimum resource allocation was not obtained under the existing tenure agreements.

Credit facilities were ample for the area being furnished by the Federal Land Bank, Production Credit Associations, Farm Security Administration, local banks, and private sources. Resource adjustments suggested further need for long time loans for buildings, as well as a material expansion of production credit demands because of increased operating expense.

Programs for both youth and adult agricultural education were well supplied.

Directive production control was promoted by Soil Conservation Service, Agricultural Adjustment Administration, and Farm Security Administration. The Soil Conservation Service encouraged good land husbandry most of which could be done by the individual farmer with a limited amount of hired technical skill which could be obtained locally.

[1] Doctoral thesis number 927, submitted August 5, 1948.

[2] In cooperation with the Department of Farm Economics, University of Kentucky.

Certain phases of water runoff control and drainage problems were of a community nature requiring cooperative action.

The Agricultural Adjustment Administration provided incentives for securing the active participation of farmers in erosion control practices which increased the pasture and roughage production of the area. In so far as acreage of crops, such as tobacco, were frozen in a production pattern without regard to areas of comparative advantage or changes in technology which changed the cost structure, optimum resource allocation was prevented. As a result, production costs increased which were passed on to the consumer without any gain to the producer.

The Farm Security Administration substituted control of the management factor for part of the equity formerly required to make a loan sound. This substitution rendered a service. In executing the loan program for tenant purchase of farms, a plan allowing too small an amount of capital and requiring too high qualifications for applicants was followed. As a consequence the farms tended to be too small, and the purchase of a farm by the tenant was only speeded up when the tenant-purchase client was the type who would have soon purchased the farm on his own.

Reconnaissance of Type-of-farming Area VII and geological studies showed three topographic areas. First, the level land subjected to regular overflow; second, level to undulating land rarely if ever subjected to overflow; and third, rolling to hilly land forming the dividing ridges of the drainage systems. Soil classification indicated three soil areas. Loessal deposit covered most of Area VII.

Area VII, therefore, comprising 6 per cent of the land area of Kentucky and containing 10,186 farming units was divided into three land class areas: first, Ohio River overflow land, Land Class Area A; second, level to undulating land, Land Class Area B; and third, rolling to hilly land, Land Class Area C.

Land Class Area A contained 13 per cent of the land of Type-of-farming Area VII with about 70 per cent of the land tillable. Examination of tillable land and depleting crops for four subareas of this land class suggested significant differences between A_1 and A_2, no significant difference between A_2 and A_3, and highly significant difference between A_3 and A_4.

Land Class Area B contained 35 per cent of the land of Area VII and had 3,254 farming units. Land Class Subareas B_1, B_2, and B_3 separately located showed no significant difference in tillable land or depleting crops. Subareas B_3 and B_4 were significantly different in tillable land. B_4 and B_5 had a significant difference in tillable land. B_5 and B_6 were not significantly different in tillable land or depleting crops. B_6 and B_7 were significantly different in tillable land. B_7 and B_8 had highly significant differences in tillable land and depleting crops.

Land Class Area C made up 52 per cent of the land of Area VII, contained 5,665 farming units, and 60 per cent of the area was tillable. Soil productivity, land use, and location suggested nine subareas. Subarea C_1 showed a highly significant difference from C_2 in tillable land

and depleting crops. C_2 showed a highly significant difference from C_3 in tillable land, depleting crops, and corn acreage. C_3 had a highly significant difference in tillable land and a significant difference in depleting crops and corn acreage from C_4. C_4, C_5, C_6, and C_7 were not significantly different in tillable land, depleting crops, or corn acreage. C_7 and C_8 had a highly significant difference in tillable land and depleting crops. C_8 and C_9 had a highly significant difference in tillable land.

Typical farms for budgeting adjustments to obtain optimum resource allocation were selected for the subclass areas showing significant differences in tillable land, depleting crops, corn acreage, or containing a significant number of the farms of a land class area. The typical farm was an actual operating unit most nearly approximating the median organizational factors such as tobacco, corn, wheat, soybeans, and hay acreage with the accompanying dairy cow, beef cow, and hog numbers for the subarea.

Subareas A_1, A_2, and A_3 were considered together with two farms being used as typical—a 52-acre farm and a 225-acre farm. A 113-acre farm was chosen as typical of Subarea A_4 which represented 53 per cent of Land Class Area A. Land Class Area B had farms selected as typical of Subareas B_3, B_4, B_5, and B_7. Land Class Area C was represented by typical farms from Subareas C_1, C_2, C_3, and C_5.

A comparison of acres of principal crops and numbers of livestock for the 1940 census enumeration and the calculated typical farms applied to Area VII showed a reasonable similarity. Crop and livestock sales indicated for both census and typical farms showed a high degree of similarity.

Use of typical farm systems in approximating very closely the actual situation presented by the 1940 census data, suggested the validity of selecting typical farm systems from which to budget the proposed allocation of resource adjustments. To budget the proposed systems, production standards for crops and livestock were necessary.

Results of production from wisely chosen and correctly combined crop and livestock enterprises on farms of successful operators linked with experimental results and judgments of experienced workers at the Kentucky Agricultural Experiment Station furnished the basis of determining production requirements. Budgeted plans were used to show potentially possible results from optimum resource adjustments.

Crop yields were approximately 30 per cent higher for the upper quartile of farms than for all the farms included in the random sample of farms. Land Class Area A had better yields than the other areas with the exception of barley, while Land Class Area C had the lowest yields.

Land use and cropping practices such as contour cropping and terracing increased corn, wheat, and hay yields. Mechanization, better work methods, efficient crop and livestock production increased labor accomplishment. Normalized production requirements of crops were determined by land class areas, whereas livestock production requirements were present on the basis of the type-of-farming area only.

Prices paid and received by farmers were those actually reported

by farm account-keeping cooperators during 1939, 1940, and 1941. In this connection a dynamic forward pricing program which allowed technological changes to have their influence on costs would encourage more economical allocation of resources. In a way the use of a static framework of prices set a situation certainty that could be budgeted. Seasonal price guarantees would allow more frequent shifts and thereby keep resources in a more economical allocation adjustment.

Income was low for adequate farm-family living as evidenced by only $222 labor income per farm. Thus, on the average, an adequate living standard had to be sacrificed in order to accumulate savings toward farm ownership.

A summation of the results of resource allocation adjustments as shown by a budgetary analysis of the typical farms indicated a potentially possible labor income six times that for the typical systems under 1939, 1940, and 1941 price relationships. Land resources were to be employed on the basis of capabilities with good land husbandry practices which would result in a higher degree of intensity in land use. Labor resources supplemented with mechanization were to be more fully employed upon productive enterprises by increasing livestock enterprises with high labor demands requiring more uniform use of labor throughout the year. Better work methods were planned for the tobacco enterprise. Capital outlays were to be increased by soil conserving practices, use of commercial fertilizers, greater mechanization, and more adequate housing of livestock.

Labor income was calculated to increase from $1.05 per day of productive labor for the typical systems to $3.96 per day for the proposed systems. Total receipts were to be trebled and expenses were to be doubled while labor income was to increase from 1.9 million dollars for the typical systems to 10.9 million dollars for the proposed systems on an area basis. Farm investment was to be increased 18 million dollars. Farm operators were calculated to average $906 more labor income for family expenditures under the proposed farming systems than for the typical farming systems. Also, sufficient supplies of pork, eggs, poultry, milk, butter, fruits, and vegetables were to be provided for an adequate level of living.

Labor and investment income or farm income was calculated to increase from 5 million dollars for the typical farming systems to 15 million dollars for the proposed farming systems of Type-of-farming Area VII, Kentucky. This income represents the amount of income that the farm family was expected to have available for the farm-family living expenditures, interest payments, debt retirement, and savings. Potential possibilities for increasing labor and investment income were calculated to be slightly greater for the better land as indicated by an increase of $879 per farm for Land Class Area C, $1,058 per farm for Land Class Area A, and $1,180 per farm for Land Class Area B.

Uncertainty of price, production, and compensation for capital outlays limited the resource allocation adjustment, accounting for a large part of the difference in income between the typical and proposed systems.

The labor and investment income potential possibilities, resulting from adjustments in obtaining optimum allocation of resources as presented in this thesis, were assumed to be effected essentially under a price guarantee (static price for 1939, 1940, and 1941), production insurance, and tenant compensation for unused added improvements.

Uncertainty, risk, and institutional arrangements are forces conditioning the use of resources by the individual farm. Price and production variations are uncertainties limiting the attainment of the income of the proposed farming systems. Leasing agreements add further difficulty to maximization of income. Finally the firm and household relationships further inhibit the realization of the proposed income by diminishing the profit motive and emphasizing the consumption factor. With improved mobility of the labor force and proper evaluation of individual freedom and leisure, the labor and investment income represents the movement toward which the agriculture of the area should move in making optimum use of resources.

THE ABOVE AND BELOW GROUND RELATIONSHIPS OF ALFALFA-GRASS MIXTURES[1]

DOUGLAS SCALES CHAMBLEE

From the Departments of Agronomy and Botany
Iowa State College

Experimental plots for the investigation of alfalfa-grass mixtures were located on a Cecil sandy clay loam near Raleigh, North Carolina. Three separate experiments were conducted concurrently, and are summarized as follows:

EXPERIMENT I

In this investigation, a study was made of some of the above and below ground relationships of alfalfa and orchard grass. The two species were grown in rows spaced 6 inches, with and without partitioned root systems. Each species was planted in pure stands, and also in alternate rows. A study of the above ground associational effects was facilitated by partitioning the root systems with sheet metal barriers. The above ground parts were allowed to intermingle; whereas, the below ground parts were separated. The soil was excavated, in layers of 6 inches, to a depth of 30 inches. Before replacing the soil, asphalted sheet metal partitions, extending downward to 30 inches, were placed vertically six inches apart in one-half of the excavated area of each replication. In the other half of each replication, the root systems of alfalfa and orchard grass were not separated by sheet metal barriers. Bouyoucos' moisture blocks were placed at depths of 3, 6, 12, 24, and 30 inches, directly under certain rows, as the soil was replaced in its original position. The seedings were made September 1, 1947. Soil moisture readings were made on fifty-five days, from April 21 to September 20, 1948. The plots were harvested four times during the season.

It was evident that orchard grass was benefited by both its above and below ground associations with alfalfa. It is postulated that the air and soil temperatures were reduced to an optimum level for growth of orchard grass by the larger canopy of growth produced by alfalfa. There was evidence of above and below ground competition between alfalfa plants for the various growth factors. Alfalfa produced more growth when grown between two orchard grass rows than when grown between two alfalfa rows, in both partitioned and nonpartitioned plots. Orchard grass was not as competitive for the growth factors as alfalfa, either above or below ground.

The roots of alfalfa and orchard grass permeated the soil to a maxi-

[1]Doctoral thesis number 965, submitted June 6, 1949.

mum depth of 36 inches in 12 months. The alfalfa roots were well distributed downward to 36 inches; however, a large proportion of the orchard grass roots were located in the upper 12 inches. Alfalfa removed soil moisture at all depths as rapidly or more rapidly than orchard grass when equal growth was produced by both species. At the lower depths of root penetration, alfalfa removed soil moisture more rapidly than orchard grass.

Resistance readings of 75,000 ohms have been arbitrarily used by several investigators as an indicator of the wilting percentage. A dryness of 75,000 ohms was obtained most frequently at the 12-inch depth under both species. The soil dried more rapidly at the 3-inch level, after wetting, than at lower depths. On 58 per cent of the reading dates, resistances higher than 10,000 ohms were obtained at the 3, 6, 12, 24, and 30-inch levels under alfalfa. On 22 per cent of the reading dates, the soil was dryer than 75,000 ohms at these depths. It was evident that moisture frequently becomes insufficient for maximum growth of alfalfa in North Carolina.

EXPERIMENT II

In this experiment three methods and five rates of seeding alfalfa-orchard grass and alfalfa-tall fescue were studied. Comparisons were made between alternate row, mixed-in-the-row, and broadcast methods of seeding. The spacing between rows was six inches. Rates of seeding, ranging from ten to twenty pounds of alfalfa, and five to fifteen pounds of grass, were evaluated. During the two years of this study, nine harvests were made.

An average of all methods and rates of seeding for the two years showed no differences in total yield between alfalfa-orchard grass and alfalfa-tall fescue. In the first year, reductions in total yields were obtained from plots receiving a high seeding rate of grass, and those receiving a low seeding rate of alfalfa. In the second year, there were differences in total yields between methods of seeding. The alternate row plots produced less forage than the broadcast or mixed-in-the-row plots.

Seedling counts, three weeks following fall seeding, showed that seedlings were initially established in proportion to the rate of seeding. Botanical separations, in spring and summer, demonstrated that less alfalfa was present in plots which had received a high seeding rate of grass. Similar yields of grass were obtained from plots receiving high seeding rates and those receiving low seeding rates. Since lower total yields were obtained from plots receiving high seeding rates of grass, it was evident that the grass had influenced the establishment and growth of alfalfa prior to the harvest dates for hay. In the alfalfa-grass mixtures, alfalfa produced more growth in broadcast plots than in mixed-in-the-row or alternate row plots. The grasses, in general, responded inversely. Tall fescue tended to suppress the growth of alfalfa more than orchard grass.

EXPERIMENT III

Alfalfa-orchard grass and alfalfa-tall fescue were seeded in narrowly and widely spaced alternate rows, 6 and 12 inches respectively. The forage was harvested on the same dates as in Experiment II.

Tall fescue was favored by wide spacing of rows; whereas, orchard grass produced less forage per acre in widely spaced rows. It was evident that the highest yielding mixture under narrow spacing may be the lowest yielding mixture under wide spacing. The increase in growth of the individual species, in widely spaced rows, was not sufficient to justify the wider spacing.

Orchard grass and tall fescue analyzed similarly in percentage nitrogen.

RELATIONSHIP OF MICROORGANISMS TO THE DISAPPEARANCE OF RANCIDITY IN CHEDDAR CHEESE[1]

VIRGIL ARTHUR CHERRINGTON

From the Department of Dairy Industry, Iowa State College

Rancidity is a defect that occurs in certain lots of cheddar cheese and is usually associated with fat deterioration. It has been observed, however, that cheese which becomes rancid, because of the homogenization of the raw milk or the addition of udder tissue extract, frequently loses the odor and taste of rancidity during the ripening process. Usually such cheese becomes a desirable product.

In considering the relationship of microorganisms to the disappearance of rancidity in cheddar cheese, it seemed logical to assume that lipolytic organisms might be of importance since a number of these organisms are capable of utilizing the products of fat hydrolysis. In attempting to isolate lipolytic organisms from cheddar cheese, the flora of normal cheese was studied. Only a few lipolytic organisms were ever found. The organisms that were most prominent were *Streptococcus lactis* and certain micrococci.

In order to determine whether any of the organisms isolated could utilize butyric acid, a loop of each culture was transferred into tubes of a synthetic medium in which sodium butyrate was the sole source of carbon. Sodium butyrate was used because even low concentrations of butyric acid are toxic to many organisms. The medium used was prepared according to the general formula of Ayres, Rupp, and Johnson (1) and had the following composition:

Sodium ammonium phosphate	2.0 grams
Potassium chloride	0.1 gram
Salt of fatty acid	5.0 grams
Distilled water	1,000.0 ml.

None of the organisms isolated, non-lipolytic or lipolytic, appeared to utilize sodium butyrate.

The failure of organisms isolated from cheddar cheese to utilize sodium butyrate suggested the inoculation of small quantities of cheese into the synthetic medium to determine whether uncultured species in the cheese might be capable of butyrate utilization. Samples of cheddar cheese were emulsified in sterile 2.0 per cent sodium citrate solution and inoculated into tubes of the butyrate medium. After incubating four or five days at 21.0°C. turbidity developed in each tube, and large rod-shaped organisms were recovered. These organisms were obtained

[1]Doctoral thesis number 616, submitted June 3, 1941.

in practically pure culture from more than 200 samples of cheddar cheese from various sources. The organisms grew readily on tomato juice agar and were arbitrarily designated the X-type organism. They were found to be non-lipolytic on natural fat agar and on Nile-blue sulfate agar. When inoculated into litmus milk, acid and gas were formed. After these organisms had grown in lactose broth, they were found to be small, gram-negative rods which conformed to the accepted description of *Escherichia coli.*

Since the X-type organism regularly developed in the butyrate medium inoculated with cheddar cheese, the question arose as to how the addition of small quantities of butyric acid would affect the flora of cheese. In one-day-old cheese made from raw milk containing added butyric acid, enormous numbers of *S. lactis* organisms were present. The numbers of these organisms in the cheese were essentially the same as the numbers in normal cheddar cheese of the same age. Few organisms of any other type were observed. After the cheese had ripened three or four days, *S. lactis* was no longer detected and was replaced by X-type organisms. After the cheese had ripened fourteen days the X-type organisms diminished in numbers. With their disappearance a more or less typical cheddar cheese flora was observed. Similar observations were made when cheese was made from pasteurized milk containing added butyric acid, but the numbers of the X-type organisms that developed were usually not as large as with the raw milk cheese. These experiments were repeated many times, great care being exercised to eliminate the possibility of contamination. In some cases the cheese was made with pure cultures of *S. lactis* instead of cheese culture, and still large numbers of the X-type organisms were observed. It appears that the X-type organisms developing in cheese containing butyric acid are variants of *S. lactis.* As the flavor and odor of butyric acid disappeared from the cheese, many of the organisms seemed to return to their original form.

All lots of cheese made from milk containing added butyric acid were very rancid when one day old. However, cheese made from pasteurized milk lost much of its rancidity after three or four days, and raw milk cheese was definitely less rancid at the same age. After the cheese had ripened fourteen days, most of the rancidity had disappeared in both the raw and pasteurized milk cheese.

The bacterial flora of seven-day-old cheese made from homogenized raw milk usually consisted of rather large numbers of the X-type organisms. When the homogenized milk was held two hours before it was made into cheese even larger numbers of the X-type organisms developed. However, cheese made from milk that was homogenized and immediately pasteurized showed very few of these organisms. The X-type organisms seemed to develop less rapidly in cheese from homogenized milk than in cheese from raw milk containing added butyric acid; however, they appeared to persist in the former cheese for a longer period of time.

Cheese made from homogenized raw milk always became rancid. However, cheese made from milk that was homogenized and immediately pasteurized did not become rancid. Rancidity developing in cheese from homogenized raw milk persisted for a longer period than rancidity in cheese from raw milk containing added butyric acid. Presumably, in homogenized raw milk cheese the lipase continued to act on the fat and set free butyric acid during the ripening process. This would explain why the rancidity persists over a longer period of time.

Inoculation of pure cultures of the X-type organism into cheese made from milk containing added butyric acid did not accelerate the rate at which this type of rancidity disappeared; the rancidity disappeared as rapidly without the inoculation as with it. Similar inoculations were made into homogenized raw milk used in cheese manufacture. Here, as in the case of cheese made from milk containing added butyric acid, rancidity disappeared rapidly either with or without inoculation. When milk containing pancreatin was made into cheese, both the inoculated and uninoculated lots became more rancid as the product aged. Lots of cheese four months old were so rancid that they could not be judged. Presumably, the environment produced by the pancreatin was so unfavorable that few organisms were able to survive.

The X-type organism did not grow well when inoculated into the sodium butyrate medium. Growth was obtained by transferring rather large amounts of inoculating material, but even then only a slight turbidity developed. Better growth was obtained when the butyrate medium was enriched with small quantities of peptone or lactose or both. However, acidifying and distilling the medium and titrating the distillates showed that little or none of the butyrate had been utilized. The ability of the X-type organism to utilize butyrate was further studied by adding sterile sodium butyrate solution to active cultures growing in dilute yeast extract broth. Under these conditions the organism utilized the butyrate. Disappearance of butyrate was apparent after fourteen days at 21.0° C. and was more complete after twenty-one days. These observations indicate that the X-type organism has the ability to bring about the disappearance of rancidity in cheddar cheese.

In attempts to produce the X-type organism from pure cultures of *S. lactis* in the laboratory, a number of media containing varying amounts of sodium butyrate or butyric acid were studied. The attempts were not always successful. Best results were obtained when tubes of the butyrate medium containing 0.1 per cent peptone were inoculated with 0.1 ml. of a vigorous 48-hour litmus milk culture of *S. lactis*. Frequently, however, it was necessary to incubate the enriched butyrate medium cultures for a week or more at 21.0° C. before the X-type organism developed. Sometimes a culture of *S. lactis* had to be transferred in the medium several times before a change could be noted. There seemed to be no uniformity in the time required for the change to take place in the cultures studied.

Inoculation of litmus milk, containing sodium butyrate or butyric acid, with 0.1 ml. quantities of *S. lactis* failed to produce any change in the *S. lactis*. It seems likely that the lactose in milk is such a readily available source of carbon for the organism that it does not utilize the added sodium butyrate or butyric acid. On the other hand, the synthetic medium contained sodium butyrate as the only source of carbon and in order to utilize it the organism may have been forced to change its general characteristics.

It seems that the formation of the rod-shaped organism from pure cultures of *S. lactis* depends on a rather delicate balance of a number of factors. Some cultures of *S. lactis* changed into rod-shaped organisms rather readily while other cultures did not change until they had been transferred a number of times. Furthermore, the amount of culture transferred appeared to be an important factor in the development of the X-type organism. When only a small loop of an *S. lactis* culture was transferred to the medium containing butyrate, it was difficult to obtain the large rods. The difficulty experienced in regularly producing the X-type organism in the butyrate medium inoculated with *S. lactis* perhaps can be ascribed to the inability to reproduce the conditions occurring in cheddar cheese.

The data presented indicate that the disappearance of rancidity in cheddar cheese is due to the activity of microorganisms. In young cheddar cheese large numbers of *S. lactis* organisms are normally present, but the readily available food supply is limited. It seems probable that these organisms utilize butyric and other lower fatty acids as a source of carbon. In order to utilize these acids under the environmental conditions present in cheddar cheese, *S. lactis* is forced to change its morphological and physiological properties to those of the X-type organism. With the disappearance of rancidity in cheddar cheese the X-type organism decreases in numbers and is replaced with a more typical cheddar cheese flora.

LITERATURE CITED

1. Ayres, Henry S., Phillip Rupp, and Wm. T. Johnson, Jr.
1919. A study of the alkali-forming bacteria found in milk. USDA Bull. 782.

PROPERTY TAX LEVIES IN UTAH[1]

HAROLD HARRIS CUTLER

From the Department of Economics and Sociology
Iowa State College

Because of increased costs incident to World War II, increased demand for government services, the very pressing need for an extensive building program because of war-imposed deferments, the revenues of the State of Utah and its political subdivisions proved woefully inadequate. As a result the 1945 Utah legislature set up an interim Tax Study Committee to make a thorough investigation of the tax structure of Utah and to make recommendations to the next legislature.

This study constitutes a part of the property tax division of this larger assignment. This study is concerned with past, present, and prospective future property tax levies. A companion study of property assessments was undertaken by the Utah State Tax Commission. Legal maxima levies for the State of Utah and its subdivisions were traced from the year of admission to statehood in 1896 to 1945. Actual levies were traced from 1916 to 1945.

The year 1916 was chosen as the starting point for actual levies because at this time a serious effort was made to assess property at its full value as provided by law. This objective was never realized because of practical difficulties and the law was changed by the 1947 legislature providing for assessment at 40 per cent of value.

Railroads, utilities, and mines are assessed by the State Tax Commission. This property amounts to about 40 per cent of total assessed valuation. The balance of the State's property is assessed by the county assessors supervised by the Tax Commission. The law provides for a general tax on all property. However intangibles are exempt, being subject to the income tax only. Also property owned by the various governmental units, churches, and charitable organizations is exempt. Approximately three-fourths of the land area of the state is owned by the Federal government. This results in a rather narrow property tax base. Total assessed valuation has ranged from $531 million in 1926 to $728 million in 1930 and stood at $672 million in 1945.

The over-all weighted average property tax levies in Utah have ranged from 16.53 mills in 1916 to 35.07 mills in 1939 and stood at 34.16 mills in 1945. While assessed valuation increased approximately one-fourth, levies more than doubled from 1916 to 1945.

Permissive property tax levies for State purposes have decreased from 8 mills in 1896 to 2.4 mills in 1945. At a general election in 1946 the State constitution was amended to permit an additional levy sufficient

[1] Doctoral thesis number 948, submitted May 21, 1949.

to provide a maximum of nine-sixteenths of a minimum school program, the level of which is to be determined by the legislature. This will not only increase the levy made by the state but will increase the total levy made by all units. However, the increased state levy will be offset by reduced local levies in some districts. All of the revenue yielded by this increased state levy will be returned to the local districts for the support of their primary and secondary schools. Actual levies made by the state have ranged from 10 mills in 1934 to 2.9 mills in 1944. The plan is to devote property tax revenues exclusively to local needs.

The legal maxima levies for county purposes have ranged from 5 mills in 1896 to 24.5 mills for the smaller counties, and 19.5 mills for the larger counties in 1945. Actual median levies by the counties of the state have ranged from 3.8 mills in 1916 to 10.3 mills in 1945. The lowest levy by any county during this period was 1.4 mills by Juab County in 1918, and the highest levy was 19.9 mills by Duchesne County in 1943.

Permissive levies by local school districts ranged from 6.5 mills in 1898 to 14 mills for the county districts, and 18 mills for city districts. In addition to this an additional 2 mills may be levied by any school district upon the approval of a joint board consisting of the State Board of Education and the State Tax Commission. No legal maxima were set on levies to retire debts. As a result the intent of the law has frequently been circumvented by districts incurring debts for current operations and exceeding the limit in subsequent years to pay for it. Actual median levies by school districts for all purposes including debt service have ranged from 9.4 mills in 1922 to 14.6 mills in 1945. The lowest levy during this period by any local district was 5.4 mills by Jordan, and the highest was 20.5 mills by Beaver, both in 1945. Approximately 70 per cent of the cost of local schools came from local property tax levies in 1945. The median levy for school purposes levied by the state plus the levy by local districts ranged from 14.3 mills in 1922 to 19 mills in 1945. It was 17.5 mills in 1945.

The total permissive levies on rural property—by the state and county and rural school districts—ranged from 19.5 mills in 1898 to 41.1 mills in 1945. Actual median total levies on rural property ranged from 14.5 mills in 1916 to 28.8 mills in 1945. The lowest levy made on any rural property was 11.9 mills in 1918. The highest levy ranged from 17.9 mills in 1916 to 39.5 mills in 1945.

Permissive levies for city and town purposes ranged from 4⅓ mills in 1896 to 18 mills for towns, and from 32.4 mills for the larger cities to 44.0 mills for the smaller cities in 1945. The median levies actually made by the smaller cities and towns ranged from 6.25 mills in 1916 to 12.0 mills in 1924, falling to 10.0 mills in 1945. The lowest levies ranged from 1.0 mill to 3.0 mills, and the highest levy ranged from 18.5 mills to 33.0 mills.

Levies by the larger cities ranged from 6.5 mills in Salt Lake City in 1916 to 17.45 mills, also for Salt Lake City, in 1945.

Maximum permissive levies on urban property for all purposes ranged from 23.83 mills in 1896 to 61.6 mills for towns and 85.6 mills for

cities. Actual levies on property in the larger cities ranged from 17.9 in 1916 to 49.8 in 1935, then decreased to 46.25 in 1945. The median levies on property in the smaller cities and towns ranged from 20.4 mills in 1916 to 41.33 mills in 1933, and stood at 39.05 in 1945. The highest levy on any property in the smaller towns in 1916 was 35.7 mills. It increased to 65.0 mills in 1943 and stood at 62.2 mills in 1945.

Property taxes charged in Utah increased from $8.8 million in 1916 to $22.9 million in 1945. The proportion of total revenue for all units of government represented by property taxes decreased from 92 per cent to 34 per cent from 1916 to 1945. Property taxes represented 52 per cent of the revenue of the State government in 1916 and only 4 per cent in 1945. Property taxes have always represented the major source of revenue for local governmental units in Utah.

Since 1922 the debt of the State government decreased from $10.7 million to nothing in 1945. During the same period the indebtedness of the local units of government decreased 23 per cent, from $41.7 million to $32.2 million. The indebtedness of counties and school districts decreased by more than this percentage as urban indebtedness increased by 40 per cent. The financial plight of the municipalities in Utah is becoming increasingly serious.

While the total debt of all governmental units in the United States increased from $10.3 billion to $19.0 billion between 1922 and 1942, the total debt of all units in Utah decreased from $53.4 million to $34.8 million during the same period.

While there is a disposition on the part of the State government to leave the property tax entirely for local purposes, the increase in local needs indicates an increase in property taxes in the future in Utah.

The assessment study by the State Tax Commission showed assessments to be about 30 per cent of 1946 market values. The ratios varied between counties from 20 per cent to 35.5 per cent. Investigation showed this disparity to be more apparent than real, and steps are being taken to correct any real disparity which may exist. A program has been worked out, also, to bring assessment ratios of all classes of property into agreement at about 40 per cent of the 1940 market value.

The great depression of the 1930's reduced income and increased the need for revenue, thereby proving the existing sources of revenue inadequate. Percentage collections of property taxes charged decreased from 92.7 per cent in 1927 to 76.8 per cent in 1933. As late as 1938 property taxes were delinquent on 5 per cent of the assessed valuation and 13 per cent of the assessed acreage. This led to the introduction of many new types of taxes, the most important of which are the income tax and sales tax.

It is recommended that:

1. In order to provide a broader tax base for Utah, no tax be levied which will discourage industrial development and production in Utah.

2. Improvement and extension of the centralized system of assessment and collection of taxes. In view of the unequal distribution of the State's resources and the growing complexity and interdependence of

our economic order this practice should be extended as far as may be compatible with the safeguarding of democratic principles.

3. State income taxes, which are nominal at present may be increased and a liberal allocation made to municipalities.

4. Municipalities should impose fees for services, such as sewage disposal, to supplement the inadequate property tax revenue.

5. Rigid limitations on mill levies should be avoided.

6. Limitation of debt to a percentage of assessed value has greater merit judging from Utah experience.

7. Property tax exemptions in Utah should be thoroughly studied.

8. School districts will of necessity continue to rely largely on property taxes for support. These taxes should be centrally collected and allocated equitably among the local districts.

9. Counties will probably rely heavily upon property taxes; but funds for welfare and roads should come from other sources, the former from the sales tax and the latter from revenues associated with the use of the roads.

10. A severance tax on extractive industries graduated progressively on the basis of ratio of net to gross proceeds is desirable.

11. The assessed value of metalliferous mines should be averaged over a period of from 5 to 10 years to overcome sudden and extreme fluctuation.

CAROTENOID CONTENT OF TOMATO FRUITS AS INFLUENCED BY ENVIRONMENT AND VARIETY[1]

ERVIN LOREN DENISEN

From the Departments of Horticulture and Botany
Iowa State College

Tomato fruits were subjected to various environmental factors to determine the influence of these factors on carotenoid development. Several varieties, hybrids, and species of tomatoes were analyzed for pigment content to determine varietal differences and to explore the possibilities of finding germ plasm suitable for use in a tomato color breeding program.

A modification of the method of Zscheile and Porter (10) for extraction of tomato carotenoids was adopted for pigment analysis. Kramer and Smith's (4) method was used in one phase of the investigation, but was not as satisfactory because some carotenoids were lost in emulsions, and xanthophyll was not separated from the other pigments.

A Coleman Universal Spectrophotometer was used for measurement of the carotenoids and was calibrated for lycopene and beta-carotene by taking transmission readings of known concentrations of the two pigments in petroleum ether (Skelly B). From this information the specific absorption coefficient of 300.9 was obtained for lycopene at 4700 A. and 155.6 for beta-carotene at 4500 A. Transmisson readings of tomato extracts were converted to mugm. per gm. of fresh fruit with the formula devised by Zscheile and Porter (10).

An attempt was made to measure the lycopene and beta-carotene content of solutions which contained mixtures of the two pigments, according to the method used by Zscheile and Porter (10). However, unsatisfactory results were obtained because the instrument available was not adapted to the precise measurements required. Lycopene exerted a tremendous masking effect over the other carotenoid pigments, which made it possible to get sufficiently precise determination of lycopene content with transmission readings of the crude tomato extracts. This result confirms the work of McCollum (5) who found lycopene a satisfactory standard for spectrophotometric measurement of tomato pigment extracts.

Mature-green Rutgers tomato fruits were ripened in storage incubators at four sets of fluctuating temperatures. The first fruits to ripen were those alternated between 20° and 30°C. The temperature treatment which produced the largest amount of lycopene was the 15° and 25°C.

[1] Doctoral thesis number 951, submitted May 31, 1949.

alternation, and all other treatments were significantly lower at the 1 per cent level. The poorest colored fruits resulted from the 25°–35°C. treatment. The mean of the two temperatures of each treatment seemed to be the determining influence for lycopene production in this experiment. Earlier work (1), in which mature-green fruits were ripened at constant temperatures, showed that the optimum temperature for lycopene development in storage was between 20° and 25°C. Similar results were obtained by Duggar (2), Howard (3), Rosa (6), Vogele (8), and Went, LeRosen and Zechmeister (9).

Carotenoid development as affected by various spectral regions of visible light was studied in the field and greenhouse. The light values were obtained with variously colored cellophane bags placed over Rutgers tomato fruits at the time of fruit set. Clear cellophane bags were used for the check treatment, and aluminum foil bags and unbagged fruits were used for dark and full light treatments, respectively. In the greenhouse, the aluminum foil treatment was significantly lower at the 1 per cent point and the unbagged treatment significantly lower at the 5 per cent point. In the field, highly significant decreases in lycopene content were found for the tango cellophane, black cellophane and aluminum foil treatments. Xanthophyll content of the field-grown fruits was significantly higher at the 5 per cent level for those grown under violet cellophane and significantly lower at the 1 per cent level for the aluminum foil treatment. Light was thus shown to be essential for maximum lycopene and xanthophyll development under the conditions of these experiments. Smith (7) reported a lower content of carotenoids in fruits grown in the dark and found an increased production of total pigments under violet cellophane.

Rutgers fruits were also grown under light and dark treatments from the time of fruit set and analyzed for carotene and xanthophyll at various ages. The absence of light caused a marked reduction in both carotene and xanthophyll development. The carotene percentage of the fruits in the dark decreased with age, whereas an increase with age was found in the light treatment. A decreasing trend in xanthophyll development with age was also found in the dark treatment, but this pigment did not show a significant increase with age in the light treatment. Chlorophyll measurements were taken from the fruits of the light treatment, and a uniform quantity but decreasing percentage of chlorophyll was found as the fruits increased in age from three to five weeks after fruit set.

A factorial experiment in the greenhouse consisting of high and low levels of nitrogen, phosphorus, and potassium was used to study the effects of soil nutrients on the development of carotenoids in Rutgers tomatoes. The effects of nitrogen fertilizer showed a significant increase in lycopene content at the 5 per cent level. Phosphorus effects approached significance in increased pigment content but potassium effects showed no increase. The highest lycopene content was obtained with complete fertilizer. It is noteworthy that the treatments which produced the best foliage growth had the highest carotenoid content in the tomato fruits. It may be that soil nutrients affected carotenoid production in part

through the lowered average fruit temperatures which are prevalent in the shade of vigorous foliage.

Small tomato fruits of the interspecific cross, Rutgers (*Lycopersicum esculentum*) x Accession 160 (*L. pimpinellifolium*), were placed in respiration flasks containing varying percentages of oxygen and ripened at two temperatures. The low oxygen treatment, which consisted of approximately 1.5 per cent oxygen, caused a breakdown of the fruits in about four days. Fruits placed in 60 per cent oxygen showed a more rapid and complete development of color than those ripened in 20 per cent oxygen. Temperature and oxygen content interacted to produce the highest content of lycopene at 20°C. and 60 per cent oxygen. Oxygen content had a greater influence than temperature in the development of xanthophyll.

Comparisons were made between the fruits of twelve varieties and hybrids to determine varietal differences and to explore the possibilities of finding good germ plasm for a tomato color breeding program. No varieties were significantly higher in lycopene content than Rutgers; however, fruits of Earliana and U. S. No. 24 were significantly lower at the 1 per cent point, and the hybrid Rutgers x Jubilee was significantly lower at the 5 per cent point. No. 640, a highly colored wild *L.esculentum* type obtained from the Utah Agricultural Experiment Station, is not considered as valuable breeding material for color since it was not significantly higher in lycopene content than either Rutgers or Marglobe and has the disadvantage of smaller fruits which are deeply lobed. The probable presence of a recessive tangerine gene in the Rutgers x Jubilee hybrid may have caused a reduction in lycopene synthesis for the fruits of that cross.

Fruits of the Jubilee variety were found to have a higher content of both carotene and xanthophyll than the yellow variety, Mingold. Prolycopene was identified in the Jubilee fruits by chromatographic separation and absorption spectra.

In a comparison of *L. esculentum* (Rutgers variety), *L. pimpinellifolium* (Accession 160), and their interspecific hybrid, the lycopene content of the hybrid approached a geometric mean between the two species with the tendency toward the less highly pigmented Rutgers parent.

A red to yellow pigment ratio is suggested as a means of describing color in tomato fruits.

The spectrophotometric method of pigment analysis proved to be a highly satisfactory means of quantitative determination of tomato pigments. Four replications of each treatment were found to be sufficient. Composite samples of fruit reduced the sampling and laboratory error over individual fruit measurements.

LITERATURE CITED

1. Denisen, E. L.
1948. Tomato color as influenced by variety and environment. Proc. Amer. Soc. Hort. Sci. 51:349–56.

2. Duggar, B. M.
1913. Lycopersicin, the red pigment of the tomato, and the effects of conditions upon its development. Wash. Univ. Studies 1, No. 1: 22–45.

3. Howard, G. E.
1925. Pigment studies with special reference to carotenoids in fruits. Mo. Bot. Garden Ann. 12: 145-212.

4. Kramer, A. and H. R. Smith
1946. Preliminary investigation on measurement of color in canned foods. Food Research 11: 14–31.

5. McCollum, J. P.
1944. Color and pigment studies with different grades of tomato juice. Proc. Amer. Soc. Hort. Sci. 44: 398–402.

6. Rosa, J. T.
1926. Ripening and storage of tomatoes. Proc. Amer. Soc. Hort. Sci. 23: 233.

7. Smith, 0.
1936. Effects of light on carotenoid formation in tomato fruits. New York (Cornell) Agr. Exp. Sta. Memo. 187.

8. Vogele, A. C.
1937. Effect of environmental factors upon the color of the tomato and the watermelon. Pl. Phys. 12: 929–55.

9. Went, F. W., A. L. Le Rosen, and L. Zechmeister
1942. Effect of external conditions on tomato pigments as studied by chromatographic methods. Pl. Phys. 17: 91–100.

10. Zscheile, F. P. and J. W. Porter
1947. Analytical methods for carotenes of *Lycopersicon* species and strains. Anal. Chem. 19: 47–51.

CROSS-FERTILITY AND CYTOGENETICS OF SELECTED BROMOPSIS SECTION MEMBERS WITHIN THE GENUS *BROMUS* L.[1]

FRED CRAIG ELLIOTT

From the Department of Agronomy, Iowa State College

Plant breeding programs have emphasized and will continue to emphasize the utilization of closely related taxonomic entities in the improvement of agronomic species. Successful transfers of disease resistance from one species to another have been demonstrated in the cereals. In forage breeding programs similar transfers may be expected as the need arises.

Bromus inermis Leyss is one of the most important grasses in northern areas of the United States. Because of its wide range of adaptation, improvement programs involving this species are already under way. A cytological analysis of parental species assigned to the same taxonomic section as *B. inermis* as well as the available hybrids obtained from crossing experiments within the section seemed desirable.

Meiotic analyses of several Bromopsis section members revealed a euploid series of chromosome numbers from n = 7 to n = 35. A diploid race of *B. anomalus* and diploid and tetraploid races of *B. ciliatus* and *B. purgans* were observed. A 2n = 28 chromosome count was confirmed for *B. texensis* and 2n = 42 for *B. auleticus*, from Uruguary, South America. Root-tip mitoses of *B. erectus* from Lund, Sweden, revealed a 2n = 56 chromosome number. *B. riparius*, originally collected in European Russia, was observed to be 2n = 70.

No hexaploid forms of either *B. pumpellianus* or *B. inermis*, as reported earlier, were observed; the clones of these species examined all proved to be 2n = 56. A polyhaploid clone of *B. inermis* with a somatic complement of 28 chromosomes was discovered.

Certain irregular features of meioses characterized these complex polyploids. The number of bivalents per cell varied widely. Univalents and multivalent associations as high as eight chromosomes were frequently observed. Lagging univalents and bridges were common at anaphase stages. Micronucelei often were present in the quartet stages. Meioses in the polyhaploid *B. inermis* clone revealed a high degree of internal paring which suggested that this species may be nearly autopolyploid in its constitution.

Crossing of the diploids, tetraploids, and the hexaploid, *B. auleticus* with *B. inermis*, *B. pumpellianus*, or *B. riparius* failed. The hexaploid, tetraploids, and diploids used would be of doubtful value, therefore, as sources of germ plasm in the improvement of *B. inermis*.

---

[1] Doctoral thesis number 920, submitted July 14, 1948.

Crosses among *B. inermis*, *B. pumpellianus*, and *B. riparius* indicated a considerable degree of relationship. In most cases the F_1 hybrids were at least partially fertile as expressed in their ability to set seed under open-pollination. Cytological examination of these hybrids revealed many irregularities. As a result, the presence of barriers to complete random recombination among them would be expected. Root-tip mitoses in the same hybrids revealed varying numbers of chromosomes present from cell to cell.

The introgression of *B. pumpellianus* and *B. inermis* has undoubtedly occurred in certain areas within the North American range of *B. pumpellianus* since the introduction of *B. inermis*. Certain recombination products might be obtainable in these areas which possessed characters not found in introduced material of *B. inermis*.

Breeding programs dependent upon the validity of random sampling among gamete populations in *B. inermis* may not prove successful. The irregularity of the meiotic mechanism determined by cytological analyses in this species indicated the failure of random recombination to occur. It was shown that selected plants of *B. inermis* may not set seed with equal facility under artficial conditions of open-pollination.

Exploitation of all possible means of vegetative reproduction in the breeding program of this species is suggested. Two by two combinations of highly selected clones might reveal certain combinations which would unite well to give a desirable progeny.

The persistence of irregularities in the meiotic mechanism of *B. inermis* in spite of artificial sexual selection over a considerable period has led to the postulate that some selective value must be attached to their maintenance. Since the chromosome complement appears stable in spite of these irregularities and since the asexual stage is so dominant in nature, the possibility of a genetic system peculiarly adapted to vegetative propagation may be involved. A system in which somatic pairing and recombination among only partially homologous chromosomes at various levels of polyploidy is suggested.

THE DEVELOPMENT AND USE OF EVALUATIVE CRITERIA FOR ADULT EDUCATION IN HOMEMAKING WITH SPECIAL REFERENCE TO IOWA[1]

ROXANA RUTH FORD

From the Department of Vocational Education
Iowa State College

This study was undertaken for the purpose of developing and using evaluative criteria for adult education in homemaking, with special reference to Iowa.

Tentative criteria for both state and local programs of adult education in homemaking were formulated, submitted for consideration to a jury of forty-two competent persons, and restated on the basis of their judgments. The criteria chosen follow:

Criteria for local programs:

1. The program of adult education in homemaking is directed toward the achievement of recognized goals.
2. A major goal for the program of adult education in homemaking is the improvement of home and family life.
3. Conditions are provided to facilitate the carrying out of the program of adult education that has been planned.
4. The program of homemaking for adults is coordinated with other educational activities of the community.
5. Men and women of different ages, races, nationalities, and socio-economic groups represented in the community are served by the program of adult education in homemaking.
6. The people, who are to benefit, share in planning, carrying out the plans, and evaluating the program of adult education in homemaking.
7. Those who take part in the program of adult education make improvement in that aspect of home life to which attention has been given.

Criteria for a state program:

1. Local communities are given appropriate assistance in developing programs of adult education in homemaking that meet the needs and interests of all adults.
2. The program of adult education in homemaking is coordinated with programs of other state agencies providing educational services for adults.
3. Those, who are directly responsible, share in planning, carrying

[1]Doctoral thesis number 973, submitted June 3, 1949.

out the plans, and evaluating the state program of adult education in homemaking.

4. Training, that is continually adapted to needs within the state, is provided for pre-service and in-service teachers in the philosophy and methods of adult education as well as in subject matter areas relating to homemaking.

Practices believed to be consistent with each criterion for local and state programs of adult education in homemaking were stated. Data were then collected to show the extent to which these practices were carried out.

To obtain information concerning practices of local communities with reference to each criterion, the preliminary and final report blanks—for adult homemaking programs—which are submitted annually by vocational homemaking teachers to the state supervisor of home economics, were revised and used. Other information was elicited by the use of changed-practices check sheets and survey cards. The check sheets, which were used by women in ten classes, were developed by the local homemaking teachers from material provided by the writer. These check-sheets revealed the number and kinds of practices which had been adopted or improved as a result of attendance at adult classes. The survey cards were sent to a sample of 380 enrollees in homemaking classes for adults over the entire state. The purpose of the cards was to find whether the women found the programs in which they participated to be helpful or not, and to find what suggestions they would make in regard to future programs.

At the state level, information concerning practices carried out was obtained in two ways: first, by interviews with the state supervisor and members of the home economics education staff of the Iowa State College and, second, by an analysis of records in the office of the state supervisor.

Comparisons were made at both state and local levels between the practices carried out and those listed as desirable under the several criteria. In addition, local programs of adult education in homemaking were rated as good or poor by three state supervisors. Practices carried on in these programs were compared with reference to each criterion to discover at what points differences seemed to exist.

Among the local programs of the state, it was found:

1. About three-fourths of the communities directed their programs of adult education in homemaking toward recognized goals. A much larger proportion of good than of poor programs did so.

2. For the programs of the state as a whole, the evidence was inadequate for a statement to be made concerning their orientation. However, about one-half of the good programs and one-tenth of the poor ones directed attention to the improvement of home and family life.

3. Conditions in the communities were favorable for carrying out the programs that had been planned. There were no evident differences between the good and poor programs in this respect.

4. There was little evidence of coordination of adult education activities, although much cooperation between homemaking teachers and leaders of other adult education groups was reported. The teachers associated with good programs cooperated with others to a greater extent than did those in poor programs.

5. Although new individuals and groups were served by the programs of adult education, the effectiveness of the programs in serving the entire community was somewhat hampered, perhaps by a lack of awareness of differing needs and interests. A greater percentage of young women were present in poor than in good programs. With this exception, there was no appreciable difference between the good and poor regarding those enrolled.

6. In about three-fourths of the communities, those who took part in the program shared in planning, carrying out, and evaluating it. Participants in the good programs took a much more active part in every phase of the program than did those in the poor.

7. The participants for whom information was available made improvements in homemaking practices as a result of attendance at adult classes. The number of practices adopted or improved was similar for those in both good and poor programs.

At the state level, it was found:

1. Local communities were given assistance in developing their programs of adult education in homemaking.

2. There was little evidence of coordination of the program of adult education in homemaking with that of the other agencies concerned with the education of adults. The administrators of the state program availed themselves of opportunities for cooperation in many instances.

3. Although there was fine cooperation between the state supervisory staff and the home economics education department of the Iowa State College (the major institution for teacher-education in home economics in the state), the teachers and superintendents had no direct voice in the state program.

4. Training in the philosophy and methods of adult education and in subject matter areas was available.

On the basis of these data, new report forms and a program rating sheet were proposed, suggestions for strengthening local and state programs were given, questions for further study were identified, and a proposal for further research and validation of the criteria was made.

PHYSICAL AND PEDOLOGICAL PROPERTIES OF LOESS SOIL AND ITS HIGHWAY USES[1]

PING KAN FUNG

From the Department of Civil Engineering
Iowa State College

Loess deposits are widely distributed over the world. The heaviest deposits are found in the central part of North America, covering several of the mid-western states; in Europe, extending from north-eastern France and Belgium to southern Russia; in Asia, covering the greater part of north-central China; and in South America, forming a broad belt across the plains region of Argentina and Uruguay. Slight deposits are also found in the northern part of Africa and the central parts of Australia and New Zealand.

Although geologists vary somewhat in their opinions in regard to the origin of loess deposits, they all seem to agree that the bulk of loess is transported and deposited by wind. They have also more or less agreed that the optimum time of loess accumulation was at the time of maximum glaciation. The depth of loess deposits varies, but it is not unusual to see deposits two hundred feet or more in thickness. An outstanding characteristic of loess is its ability to stand in a vertical cliff. However, this is only true with the unweathered deposits. Chemically, all loess deposits are similar in composition, with SiO_2 present in the largest amount.

A detailed study was made on two loess samples obtained from the deposits in Iowa. They were both Peorian loess, which is, geologically speaking, the youngest of the loess deposits. One loess soil was sampled from Harrison County, and the other from Johnson County. The Harrison County sample, as far as can be determined, has been subjected to little or no weathering, while the Johnson County sample has been exposed to some weathering.

Physical and pedological studies were made on the two loess samples. They were subjected to a series of analytical tests in the laboratory to determine their properties and behaviors under favorable and unfavorable conditions. The geological and historical background was also investigated carefully through library research and personal correspondence with other workers along this line. Some of the data and results were presented by the author in his thesis for the degree of Master of Science.

One of the main items in the investigation was the particle size distribution study. Three methods—the Bouyoucos Hydrometer Method,

[1]Doctoral thesis number 969, submitted June 6, 1949.

the Long-Arm Centrifuge Method, and the Pipette Method—were used here. The important finding was that the method and the time of shaking or stirring of the soil-water suspension has great influence on the degree of dispersion of the system. Daxad-23 was also found to be unsuitable as a deflocculating agent for the loess samples. Next, the Differential Thermal Method was used to determine qualitatively the clay minerals present in the samples. The resulting thermal curves seemed to indicate the presence of montmorillonite-type and illite-type clay minerals in the soils with montmorillonite present in larger quantities. Base exchange studies were made on the loess passing U. S. No. 20 sieve fractions and 2 micron fractions. The exchange capacities for the two loess soils were found to be quite high, which again indicates the presence of montmorillonite. Frost action and erosion characteristics in loess were also included in the study. The data obtained indicates that the Harrison County type loess subgrades are subject to fairly serious frost heaving, and the Johnson County type loess subgrades are subject to little or no frost action. Erosion is more serious in the Harrison County type loess than in the Johnson. The presence of a higher clay content in the Johnson County type loess may have accounted for the more favorable behavior of the soil under the two adverse conditions.

The second part of the investigation consisted of a study of the different methods for stabilizing loess. (1) Some light surface road-oils—MC-O asphalt and P-1 tar—were tried. They were used for the purpose of water-proofing and increasing the cohesion of the soil particles. A series of tests were performed on the soil-bitumen admixtures to determine the suitability and effectiveness of the bituminous materials as stabilizing agents for loess. The results of the tests indicate that bitumen alone cannot stabilize loess soils satisfactorily. (2) A cationic chemical, Armac T, was used with the two loess soils. This chemical when added to some soil is supposed to cause cationic exchange phenomenon in the soil and thus render the soil water-repelling and oil-loving. Tests were performed on the Armac T treated loess for the effectiveness of the cationic chemical as a stabilizing material. Bituminous material was also tried on the chemically treated soil to investigate the effectiveness of the chemical in rendering loess oil-loving. The results show that the cationic chemical gives satisfactory oil-loving quality to the loess. However, it was found that the presence of an excess amount of Armac T in the two loess soils tends to decrease the water-proofing quality of the chemical. (3) Portland cement was next used to stabilize the two loess samples. Three different percentages of cement were tried with each loess sample using the standard Proctor densities and their corresponding optimum moisture contents as the compaction standard. Each group of soil-cement specimens were subjected to the Unconfined Compression Test, the Freeze-Thaw Test, and the Wet-Dry Test to evaluate the correct percentage of cement to be used with each loess soil and also the suitability of cement as a stabilizing agent for

loess. The results obtained from this series of tests were compared with the results obtained for another series of tests in which the soil-cement specimens were compacted to modified Proctor densities at their corresponding optimum moisture contents. It was found that Portland cement makes a very favorable stabilizing agent for loess, especially with the Harrison County sample, and that moisture and not density is the controlling factor for successful loess soil-cement stabilization.

The sand-bitumen and aggregate stabilizations of loess, which were presented in the first paper, have not been included in this study.

THE DEVELOPMENT OF EXPERIMENTAL MANAGEMENT AREAS FOR THE RING-NECKED PHEASANT, *PHASIANUS COLCHICUS TORQUATUS* GMELIN, IN NORTHERN IOWA[1]

WILLIAM EDWARD GREEN

From the Department of Zoology and Entomology, Iowa State College

It would have been difficult for the early pioneers in Iowa to visualize such shocking exploitation of natural resources as has taken place during the last half century. The early adventurers found a plethora of game. There were abundant prairie chickens, sharp-tailed grouse, ruffed grouse, waterfowl, quail, and wild turkeys to be found on the virgin prairies and in the woods with which Iowa was covered. Deer and bison were indigenous to Iowa, where they were found on the tall grass prairies and in the wooded edges. According to Schwob (1944) Iowa probably supported one of the greatest wild life populations on the North American continent. Little did the first settlers realize that such a resource could be drained as it has been drained in the past few decades.

Today Iowa is faced with a real problem if it is to enjoy wild life. It is too late to do anything about many of the native species. With the passing of several native game birds, exotic species have been introduced to take their place, and today northern Iowa depends to a large extent on the ring-necked pheasant for its hunting.

Game management in an intensively cultivated state such as Iowa, where 96.6 per cent of the land is in farms having an average value of $160 per acre (Iowa Yearbook of Agriculture, 1937) is a problem that must of necessity take the farmers into consideration if it is to achieve any measure of success. About 86 per cent of the state may be considered potential hunting area. It follows, then, that practically all game in the state must be produced on privately owned land.

The Iowa State Conservation Commission is faced with the problem of encouraging game management on the farm at a minimum cost of supervision and administration, and in such a way that a sustained annual yield will be assured.

In 1935, in an effort to obtain information that would contribute toward solving the farmer-sportsmen problem, two different types of areas were set up in the quail range in southern Iowa, and two types in the pheasant range in northern Iowa. This thesis concerns itself with the pheasant areas in northern Iowa, especially the Experimental Pay Shooting Game Management Area in Winnebago County.

[1] Doctoral thesis number 926, submitted August 2, 1948.

An investigation of pheasant populations in relation to food and cover, land use, and management practices was conducted on this Pay Shooting Area in Winnebago County (2,587 acres) as well as on a Farmer-Sportsmen Game Management Area in Cerro Gordo County (2,400 acres) from October, 1935, through July 16, 1938. Following that time, intermittent visits were made to the areas, and correspondence with members maintained in order to keep advised of developments on the two areas.

Prior to the establishment of the experimental areas, winter studies were made on a 4,908 acre tract in Winnebago County, a portion of which was later included in the management area there, when the management areas were established in the spring of 1936.

A wide variety of cover was available to pheasants on both of the experimental areas. Most classes of game cover were well represented.

Natural food conditions were good on both areas. Insects, farm grains, and weed seeds supplied an abundance of food during most times of the year. Such food was not always available in severe winter weather without birds ranging some distance in order to feed.

Predators were rare on both areas, and predator losses were slight.

Winter losses occurred throughout the study. In the winter of 1935-36, mortality from climatic causes amounted to 48.2 per cent of the pre-winter populations. In the winter of 1936–37, there was a loss of 40 per cent; but weather losses were very low. In 1937-38, 49 per cent of the pre-winter population was lost. High poaching losses occurred and some predation was noted. During the study, winter losses averaged 46 per cent a year. Thus, whether mortality was caused by weather, poaching, predation, or unknown causes, a fairly constant loss of birds occurred each year.

The food and cover relationship was very important in the winter survival of the ring-necked pheasant. Weather losses were in direct proportion to the distance of food from cover.

In an attempt to improve the food and cover relationship, cover was planted on both areas. On the Winnebago County Area, 407 trees were planted in 21 corners. Of these, only one survived until 1948, a survival rate of 0.24 per cent. On the Cerro Gordo Area 213 trees were planted in 13 stations. Survival rate for these in June, 1948, was 5.13 per cent for conifers, 2.7 for hazelnut, and 75 per cent for mulberry.

Future plantings should stress deciduous rather than coniferous trees. Recommended species are wild plum, mulberrry, lilac, elderberry, hazelnut, wild rose, and box elder.

On the Winnebago Area farmers placed shocked grain in the planted corners, and on the Cerro Gordo Area, Gun Club members placed shelled or ear corn in the stations as winter food for pheasants.

Winnebago Area studies indicated a close relationship between climatic conditions and pheasant activities. Wind velocity had the most pronounced effect.

Nesting conditions were favorable in 1936 and 1938, when wet weather in early June delayed mowing of hayfields until after most broods came off. Dry weather in 1937 permitted early mowing and resulted in high nest destruction.

Except for seasonal variations, pheasant populations remained fairly constant during the period of study, but increased in 1939–41 to an all-time high in 1942.

It was found that spring populations of 25 birds per section can increase to 100–125 per section in one season. With this population and a sex ratio of 3:1, populations in 1936 increased to 100 birds per section by fall. In 1937, a spring population of 60 birds per section and a sex ratio of 2:1, only increased to 100–125 by fall. The 1938 spring census showed 70 birds per section, with a ratio of 1:1, but the fall numbers were the same as in 1937.

Hunting, as an instrument of management, may be desirable, as it helps maintain a more favorable sex ratio.

The Winnebago Area was an Experimental Pay Shooting Area on which farmers charged a fee of $1 per day for hunting. The Cerro Gordo Area was an Experimental Farmer-Sportsmen Area, with free public hunting permitted.

The Management Area in Winnebago County, and the Amund Hunting Club it was built around, ceased to function in 1943. Lack of hunters and irregular contact with state officials contributed to the abandonment.

By 1948, the Management Area in Cerro Gordo County and the Rockwell Rod and Gun Club sponsoring it, had ceased to function. Again lack of state contacts contributed.

It is believed that game management areas along the lines of either or both considered in this study could be made to operate without assigning a resident supervisor if some regular contact from an outside agency could be maintained from year to year. While this supervision need be neither expensive nor intensive, studies show that some supervision must be furnished if game management areas are to be developed and maintained.

EVALUTION OF CLONAL LINES OF *BROMUS INERMIS* LEYSS THROUGH STUDIES OF THEIR INBRED AND OPEN-POLLINATED PROGENIES*

VIRGIL BROWN HAWK

From the Department of Agronomy, Iowa State College

Improvement of bromegrass (*Bromus inermis* Leyss) by plant breeding has been stimulated by increased use for forage and conservation. Breeding has been based in part on data from this species and to a considerable degree on information from other cross-fertilized crops. This investigation was concerned with the relation that may exist between the performance of selected parental clones and their inbred or open-pollinated progenies. Certain other supplemental studies were made.

Forage yields of parental clones and open-pollinated progenies of seventy-eight bromegrass plants, representing three selfed generations of twenty-six lines, were determined in single row plots during two years. Clones and progenies were planted in adjacent nurseries. The design of the experiments was a split-plot arrangement with three replicates. Three variety checks were included. Sufficient selfed seed of the parental clones was obtained for a replicated yield trial of inbred progenies of one-third of the lines. Seedling vigor of sixteen strains, including four checks, was determined under four environmental conditions. Compatibility with alfalfa in alternate-row seeding was studied with open-pollinated progenies of fifteen lines and one check. Checks were named varieties of bromegrass.

In addition to forage and seed yield, several plant characters, including resistance to lodging, incidence of disease, height at maturity, and date of maturity, were measured during one year on quadruplicated single-plant hills of the clonal parents. Seed set under bag was determined in the greenhouse during one winter and in replicated field plantings during two summers.

When possible, the data obtained were subjected to statistical analysis. Where some logical relationship could be assumed, correlation coefficients between parent and progeny yields and other characteristics were calculated.

Open-pollinated progenies varied significantly in forage yield, as did the clonal parents. There was a significant, postive correlation between the yield of clonal parents and open-pollinated progenies ($r = 0.462$†). Inbred progenies tested varied in mature plant yield and

* Doctoral thesis number 919, submitted July 14, 1948.

† Exceeds the one per cent level of significance.

the yields were positively correlated with yields of the clonal parent ($r = 0.556$†) and open-pollinated progeny ($r = 0.510$†).

Each successive generation of inbreeding produced a lower clonal yield than the preceding generation (ratio was 100: 93: 85). Among generations, the open-pollinated progeny yields were substantially no different on well-established stands (ratio was 100: 99: 100). There appeared to be a transitory effect of advanced inbreeding of the parental clones on the yield of their open-pollinated progenies early in their life history (ratio was 100: 98: 87).

Seedling vigor varied with temperature, length of day, and strain of bromegrass. The relative performance of the several strains was not affected by the treatments. Seedling yields were somewhat related to yields at the hay stage ($r = 0.580$‡).

Strains varied in their competitive effect on alfalfa in mixtures and in yield of hay at two cuttings in one year. Yield of bromegrass strains planted in alternate rows with alfalfa was not closely associated with yield in cultivated rows.

Replicated hill plantings of bromegrass clones were found to be essential to a study of plant characters. The accuracy of the measurements depended upon the character under consideration. Date of maturity, plant height, degree of lodging, and yield could be measured fairly accurately. Even with four replicates, incidence of plant diseases and seed set under bag were difficult to determine. Plants differed considerably in the several characters studied but few clones were superior in all respects. Selection must be made on the basis of those characters considered most important.

Clonal lines varied significantly in seed yield per plant and per panicle. Seed yield per plant was correlated with yield per panicle ($r = 0.690$†) and sheaf weight ($r = 0.364$†). Leaf diseases and ergot had a tendency to reduce seed yields. Seed set under bag was subject to wide fluctuations and classification of lines on this basis could only be made in the broadest sense. Seed set under bag during two years was correlated ($r = 0.408$†). Amount of seed set per panicle under bag was positively correlated with seed set per free panicle ($r = 0.439$†).

Variation among plants within inbred progenies exceeded, in some cases, variation among plants within open-pollinated check varieties. In a few instances, the inbred progenies were fairly uniform. No separation of genetic variation and environmental fluctuation was possible under the experimental conditions.

On the basis of data obtained, recommendations were made for a breeding program with bromegrass. Since general combining ability, as measured by open-pollinated yields, was associated with clonal parent yields, strict selection among replicated clones should precede progeny testing. Out of those tested, five plants were selected for inclusion in a synthetic variety and further testing.

† Exceeds the one per cent level of significance.
‡ Exceeds the five per cent level of significance.

DEVELOPMENTAL MORPHOLOGY OF *LOTUS CORNICULATUS* L.[1]

HAROLD WESTBERG HANSEN

From the Department of Botany, Iowa State College

Lotus corniculatus L., birdsfoot trefoil, has been gaining in popularity as a desirable legume for use as a forage crop and in land renovation. Investigations designed to improve and develop this agricultural plant have called attention to the lack of available information as to its life history. In the present study of *Lotus corniculatus* var. *vulgaris* the principal emphasis has been placed on the development of the flower and seed.

The transition from a vegetative to a flowering apex is initiated by a broadening and lobing of the stem tip. Although seven or eight lobes representing flower primordia are usually present in the early stages, the fully developed flowering stalk commonly bears only five flowers. On the abaxial side of each flower primordium a small bract arises but remains small and inconspicuous. The five sepals of the first floral whorl originate as separate primordia, but subsequent broadening near the basal region of each brings about the formation of a tubular calyx. The second floral whorl is composed of five petals which originate as small papillae, alternate with the sepals. The petals are of the usual papilionaceous type, consisting of a standard, two alae, and two petals which fuse to form a tubular keel surrounding the anthers and style. The third and fourth whorls each consist of five stamen primordia. The growth of the region basal to the stamens brings about an apparent merging of the proximal ends of nine of the filaments; the tenth, the adaxial member of the fourth floral whorl, remains attached separately to the receptacle. The fifth and final acropetal whorl consists of an elongated carpel primordium which is transformed to a U-shaped trough by meristematic activity of two adaxial regions of cells. Continued development of these two regions and their final merging brings about the formation of a tubular carpel.

The tip of each slender staminal primordium becomes capitate and then four-lobed, thus forming an anther. Each lobe consists of a central region of sporogenous cells bounded by a tapetal layer, two rows of parietal cells, and an epidermis. Divisions of the sporogenous cells give rise to the definitive pollen mother cells. The nucleus of each pollen mother cell undergoes two successive divisions forming a diad and finally a pollen quartet; wall formation between the members of the quartet occurs after both nuclear divisions have been completed. Each

[1] Doctoral thesis number 933, submitted November 22, 1948.

microspore assumes an oval shape as seen from a lateral view but appears trilobed in end view, due to the presence of three surface grooves. Parallel developments in the tapetal layer include a great increase in size followed by a gradual shrinking and disintegration; prominent V-shaped bars develop as thickenings of the walls of the outer parietal cells. Prior to the formation of the longitudinal fissures of dehiscence of the anther, disintegration of the septa between adjacent pollen sacs takes place. At maturity, each anther thus contains two large pollen cavities.

The first indications of the developing ovules occur as two rows of minute papillae along the infolding free edges of the developing carpel. The primordia increase in length as the free edges of the carpel fuse together; the fully developed ovule is of the anatropous type. The megaspores disintegrate and the chalazal one gives rise to the female developing primordium; two successive divisions of this cell bring about the formation of a linear tetrad of megaspores. The three micropylar magaspores disintegrate and the chalazal one gives rise to the female gametophyte which consists of an egg nucleus, two synergids, two polar nuclei, and three antipodals. The nucellus disappears, leaving the embryo sac in direct contact with the well-developed integuments.

Fertilization studies were conducted on cross pollinated materials in the greenhouse. Pollen tubes were observed in the stylar canal; a well-defined zygote was present in material collected forty-eight hours after pollination.

The early proembryo consists of a linear chain of cells. Successive divisions of the terminal cell give rise to a ball-shaped structure which later becomes bilobed when the two cotyledons begin to form. The stem apex differentiates after the cotyledons and hypocotyl are well developed. Although numerous divisions of the endosperm nuclei occur shortly after fertilization, cytoplasmic divisions occur much later. The outermost row of integumentary cells becomes elongated radially to form a palisade layer and the second row forms an osteosclerid layer of "hour-glass" shaped cells. The remaining cells of the integument are parenchymatous.

The root of the seedling has an open type of promeristem with a transverse meristematic zone which extends across the apex. A stratification occurs in the inner region of the cortex as the result of cambiform activity of a layer of cells; the innermost layer of this zone becomes the endodermis. The vascular elements have the arrangement of a triarch radial protostele. Phloem elements differentiate prior to the formation of protoxylem. Secondary meristematic activity brings about the formation of a solid core of xylem surrounded by a layer of cambium and phloem. Phellogen layers develop in the pericycle and outer phloem.

Two continuous histogens, a tunica, and a corpus, are present in the stem apex, the leaf primordia, and the axillary buds. The tunica consists of a single layer of cells in which all the divisions are anticlinal, whereas divisions in the corpus occur in random planes. Procambial strands differentiate near the stem tip; in a slightly older portion of the stem, protophloem elements are visible prior to the thickening of the walls of the protoxylem. Phloem fibers develop in the outer regions of the vascu-

lar strand. In older portions of the stem, complete rings of xylem, cambium, and phloem are present. Periderm layers develop in the inner regions of the cortex of old stems.

The foliage leaf arises as a result of meristematic activity in the outer corpus near the stem apex. The simple, crescent-shaped primordium becomes five-parted as a result of the activity of marginal meristems. At an early stage, the blade consists of five to seven layers of relatively undifferentiated cells. At maturity, two layers of palisade parenchyma and approximately three of spongy cells are present. Stomates are present in both the upper and lower epidermal surfaces.

FACTORS PERTAINING TO CALCULUS ACHIEVEMENT[1]

ORLANDO CLARK KREIDER

From the Department of Vocational Education
Iowa State College

The study here reported was based upon the freshmen students who enrolled at the Iowa State College and the Camp Dodge Annex for the fall quarter, 1946. At the end of the fall quarter, 1,159 students received final marks in algebra. Of the 1,159 students, 789 male students elected curriculums requiring calculus.

Thirty per cent of the 789 students failed to take calculus during or prior to the 1948 spring quarter. These 237 students differed widely on a number of available measures from the 552 students who persevered through first-quarter calculus. Measures taken before the students entered college classes, high school average, American Council on Education Psychological Examination, and mathematics placement test scores all gave a highly significant difference between the means of the mortality groups. College measures taken at the end of the first quarter in college yielded even greater differences between the two groups. The all-college first-quarter quality point average for the 237 students was nine-tenths of a letter mark lower than for the 552 students. The difference in the algebra marks was 1.2 letter marks, and scores on an algebra achievement test yielded highly significant differences.

It was assumed that the tendency to continue to calculus is a normally distributed characteristic. The students who chose curriculums that required calculus were divided into two categories—those who persevered through first-quarter calculus and those who did not. Biserial r was used to ascertain the correlation of each of the six before-mentioned variables to the separation of the two categories. It was observed that the all-college averages with a biserial r of 0.6945 was the best single variable for separating the students who took calculus from those students who did not take calculus. The most likely point between the dichotomous categories was 1.89 on an all-college average range from zero to four. Multiple biserial R, obtained from a discriminant function, was used to ascertain the correlation of more than one of the six variables to the separation of the two categories. A small advantage was gained by combining the algebra marks and the all-college averages, which produced a biserial coefficient of multiple correlation of 0.7010.

For the 552 male students who took calculus, achievement was defined as the mark made in the course. The predictive value of each of the following variables may be inferred from its coefficient of cor-

[1] Doctoral thesis number 947, submitted May 21, 1949.

relation which follows the variable: ACE, 0.244; high school average, 0.371; mathematics placement test, 0.401; algebra achievement test, 0.474; all-college first-quarter quality point average, 0.492; and college algebra marks, 0.533. A multiple regression equation, which produced a coefficient of multiple correlation of 0.590, was developed using all six of the foregoing variables. When a similar regression was developed using only the last three or college variables, the multiple correlation was reduced to 0.558. Although this difference was small, it was highly significant. When a regression using the first three or pre-college variables was developed, the multiple correlation was 0.467. This was less than either of the college variables alone.

The 552 calculus students were divided into 401 veterans and 151 nonveterans. The mean achievement for veterans was 2.26 and for nonveterans was 2.21. The difference was not significant. When an analysis of covariance was made of calculus achievement using algebra achievement test scores, algebra marks, and all-college averages as controls, no difference was found between veterans and nonveterans.

During the year in which students in this study were freshmen, it was necessary to establish the Camp Dodge Annex to provide for the large enrollment. After one year the annex was discontinued. All of the 552 students took their calculus on the Iowa State College campus. One hundred forty-two of the 552 students had attended the annex while they were freshmen. The calculus achievement was one-fourth of a letter mark higher for campus than for Camp Dodge students. The difference was significant. When achievement was compared between campus and annex students by means of covariance analysis using algebra achievement scores, algebra marks, and all-college quality point averages as controls, the difference was highly significant.

Fourteeen of the thirty-seven teachers of college algebra during the fall quarter of 1946 had fewer than two years' teaching experience and for the purpose of this study have been arbitrarily defined as inexperienced teachers. An inexperienced teacher in calculus was arbitrarily defined as one who had fewer than five years teaching experience and who had taught calculus less than one year. The 552 calculus students were divided into the following four groups according to the experience of their algebra and calculus teachers: 83 had inexperienced teachers in both algebra and calculus, 118 had inexperienced teachers in algebra but experienced teachers in calculus, 147 had experienced teachers in algebra but not in calculus, and 204 had experienced teachers in both. By means of covariance analysis a significant difference among the four groups was found in calculus achievement. Since the two groups that had inexperienced teachers in algebra dropped below their predicted calculus marks and the two groups that had experienced teachers in algebra made marks above the predicted values, it seems reasonable to assume that the experience of the algebra teacher was a factor related to the academic achievement of students in calculus.

In summary, calculus achievement may be forecast to some extent at the time a student enrolls as a freshman. After one quarter of college

attendance, a material gain in predicting calculus achievement may be had by replacing pre-college indicators by first-quarter measurements. Calculus achievement may be affected to some extent by such nonvariable factors as learning environment and experience of college mathematics teachers.

SOME FACTORS INFLUENCING ECOLOGY AND MANAGEMENT OF THE INTERIOR BOBWHITE QUAIL (*COLINUS VIRGINIANUS MEXICANUS* L.) ON MARGINAL LANDS IN SOUTHEASTERN IOWA[1]

WILLARD DAVID KLIMSTRA

From the Department of Zoology and Entomology
Iowa State College

The life history of the bobwhite quail on marginal agricultural lands and its response to such environment were intensively studied on the Eldon Research Area located in Davis County, southeastern Iowa. The Area comprised 620 acres of State-owned land and 980 acres of privately-owned lands that bordered the State area on all sides. The border strip was included for the purpose of bringing under observation all quail utilizing the State lands and to obtain comparative data on quail responses to land management practices. A check area was included to study populations uninfluenced by a developmental and management program. This investigation extended from March 1, 1946, to April 1, 1949.

The first year of study was spent in evaluating the response of bobwhites to prevailing conditions on the State lands and border strip and checking prenesting and posthunting season populations on the check area.

Land management practices on the State lands did not favor high quail populations. The entire area was heavily overgrazed, upland areas were severely eroded, crop production was low, and one-half of the area was covered with dense stands of timber.

Bobwhites utilized only the lowlands of the Research Area during the fall and winter of 1946, and no coveys were resident on the State lands. During 1946 five of sixteen nests were found on the State area, and all were in the northern one-third. The quail avoided the large acreage of overgrazed pasture and timber on the southern two-thirds of the State area the entire year.

The better quail populations occurred on the border strip where farming practices and the resulting cover and food were favorable for bobwhites during all seasons of the year. The lowlands held the major portion of the winter coveys.

On the basis of the responses exhibited by the quail to the farming practices and the recommendations found in the literature for improved management of such deteriorated, unproductive lands, a detailed developmental and management plan was devised for the

[1]Doctoral thesis number 974, submitted June 6, 1949.

State lands. It was prepared for a five-year period and included the best known wild life and land management practices.

Basic requirements for the improvement of the State lands were: increasing soil fertility; controlling erosion; renovating pastures; managing woodland areas; providing stable sources of water and food and a better distribution of cover; and repairing roadways, buildings, and fences.

The installation of the plan by the State Conservation Commission was started July, 1946. Because of excessive costs and other factors beyond control, all practices except food patch planting and leasing the cropland were terminated July, 1947. Consequently the program was not completed as planned.

Developments accomplished on the State lands, 1946–48, included: the construction of three farm ponds; the removal of trees and brush from 30 acres of woodland; the construction of 4,450 feet of water diversions and the shaping of 2,300 feet of gullies; the repair and the construction of three miles of roadways; the repair, construction, and removal of 700 rods of fences; the removal of brush from 70 acres of pasture; the repair of farm buildings; the establishment of 900 rods of multiflora rose as "living" fences; the application of 300 tons of limestone; the cutting of 700 posts and rails; the cutting of 80 rods of fire lanes; the planting of food patches; and the seeding and plowing of miscellaneous areas. The expenditures for these developments during the three years were $14,363.14 and the farm income was $2,618.62.

The response of bobwhites to the developmental and management practices on the State area was first evident during the winter of 1947–48 when three coveys wintered in the upland where no quail were found in 1945 or 1946. No coveys were on the bottomland. These birds utilized the food and cover available in the ungrazed pastures. One covey wintered in the upland of the border strip, the same as in the 1945–46 and 1946–47 winters.

Bobwhite coveys and pairs dispersed from the State lands during the 1948 nesting season, whereas, in 1946 and 1947 quail tended to move onto these lands, particularly in the upland pasture areas. The lack of grazing in 1948 resulted in heavy, dense plant growths on the State lands which were not attractive to quail for nesting.

Increased response to the State area upland was evident in the fall of 1948 despite a sharp decline in quail populations. Prehunting season coveys on the Eldon Research Area totaled three, all in the upland; one was on the border strip, and two were on the State lands in sites not occupied the previous two years. Posthunting season coveys totaled five; all were in the upland; one was on the border strip and four were on the State lands. Prenesting season coveys in 1949 totaled seven. One was in the bottomland and five were in the upland of the State lands; one covey was in the upland of the border strip. The 1948–49 upland coveys on the State lands utilized the ungrazed pasture areas for roosting and the food patches and cornfields for feeding.

Data were obtained on forty-six bobwhite nests during 1946–1948. The largest number of nests was established during May and June. A major peak in nest establishment occurred in May and a minor one in late June.

Non-productive lands supported 78.3 per cent of all nests. On productive lands, pastures were the only areas used for nesting (21.7 per cent of the nests).

Grasses were used for nest building material in 95.6 per cent of the nests. Eighty per cent of the nests were in stands of Kentucky bluegrass.

The average number of eggs per nest for 1946–48 was slightly over 15. Clutch sizes decreased somewhat as the nesting season progressed.

Twenty-eight per cent (13) of the nests hatched successfully, with the heaviest nest losses occurring during June. Slightly over 30 per cent (10) of the nests were abandoned because of disturbance to the nests or nesting birds; climatic factors accounted for 15.2 per cent (5) of these. Predators were accredited with 57.6 per cent (19) of all the nest losses.

Data were obtained on 18 broods which averaged 13.1 birds per brood when hatched. At eight weeks the average size of broods had decreased to 9.72, indicating a loss of 28.6 per cent.

The quail populations on the Eldon Research Area were on a steady decline from the spring, 1946, to the prehunting season, 1948 (1946, prenesting, 72 birds; prehunting, 149; 1947, 48 and 133; 1948, 16 and 37). The check area populations showed a similar decrease.

The 1949 prenesting population (57) on the Research Area increased 20 birds over the 1948 prehunting population (37), indicating a 256.1 per cent increase over the 1948 prenesting population (16). These results were due to the movement of quail onto the State area during the winter months.

Inverse ratios of rates of summer gain to breeding densities were expressed all three seasons on the Eldon Research Area, but they did not result in a population increase as expected; the check area revealed a similar situation. The results from the two areas combined correlated rather closely with the Research Area data.

A COMPARISON FLUORIMETER OF HIGH SENSITIVITY [1]

FINN J. LARSEN

From the Department of Physics
Iowa State College

A device for comparing the fluorescent intensities of solutions has been developed and tested. A mercury vapor lamp is the source of ultraviolet light, while readily interchangeable filters permit the isolation of various fluorescent bands. The sensitive element is a single secondary emission multiplier tube, which is electronically switched from one side of a bridge circuit to the other. A synchronous motor drives a shutter which alternately switches the exciting ultraviolet radiation from a standard solution to an unknown. The switching is accomplished at sixty cycles per second, and the optical switching is synchronized with the electronic switching.

A pair of cathode followers are used as switching tubes and as an impedance matching device between the secondary emission multiplier and a microammeter or galvanometer. The plate supply of the 6AK5 tubes, which are used in the cathode follower circuit, is the secondary winding of a transformer. Since the tubes conduct only when the plates are positive with respect to the cathode, switching is accomplished very simply.

The current in the meter is shown to be proportional to the difference in the grid potential of the tubes. These grid potentials are produced by the current from the secondary emission multiplier as it responds to the fluorescence of the samples. The theory is confirmed by data taken on the cathode follower circuit. The data indicate a maximum error of approximately five per cent. The potential source for the secondary emission multiplier is a 1,000 volt, stabilized, half-wave power supply with a conventional resistance-capacitor filter.

The entire unit is assembled in an aluminum housing with a one-quarter inch aluminum base. The secondary emission multiplier is contained in a cover on the right-hand side of the instrument. As the cover is opened, a switch automatically removes the potential from this tube, and the cuvettes which contain the solutions under test are exposed. They may be readily changed when the cover is open. A central section houses the motor and ultraviolet lamp, while the left end contains the electronic components.

In operation, the meter in the cathode follower circuit is brought to a zero reading with a standard solution in both cuvettes. After an unknown solution is added to one cuvette, the meter will indicate an unbalanced circuit. Balance is restored by adjusting the width of a

[1] Doctoral thesis number 921, submitted June 15, 1948.

slit which controls the illumination of the cuvette nearer the operator. The change in slit width, which is proportional to the concentration difference between standard and unknown solution, is readily determined by reading a second microammeter before and after slit adjustment. This meter is connected to a photovoltaic cell by a press-to-contact switch. Slit width may also be ascertained by calibrations on the control wheel which has one hundred markings on its circumference. Accurate determination of position is made possible by an associated vernier.

The instrument was tested by using varying concentrations of quinine sulfate solution. The sensitivity of the instrument is greater than older types of photofluorometers, and the response, when the null system of taking readings is used, is linear over a wide range of concentrations.

RELEASE OF SODIUM FROM NONREPLACEABLE TO REPLACEABLE FORMS IN IOWA SOILS AND THE RESPONSE OF VARIOUS CROPS TO SODIUM FERTILIZATION[1]

WILLIAM EARL LARSON

From the Department of Agronomy
Iowa State College

The amounts of sodium released from nonreplaceable to replaceable forms in thirteen Iowa soil profiles were studied over a period of 360 days. The results were compared with the amounts of original replaceable sodium and with the amounts of potassium released. The samples were hydrogen saturated, and were incubated at moisture contents near the field capacity at room temperatures. Aliquots were removed at the end of 60, 180, and 360 days for replaceable sodium and potassium determinations.

Considerably more sodium was released during 360 days of incubation than of potassium. The range in the amounts of sodium released was from 0.05 to 0.35 M.E. with an average of 0.17 M.E. per 100 grams. The amounts of potassium released varied from 0.03 to 0.25 M.E. with an average of 0.12 M.E. per 100 grams. The soils originally contained an average of 0.09 and 0.50 M.E. per 100 grams of replaceable sodium and potassium, respectively.

The maximum rate of sodium release was during the first sixty days of incubation with a somewhat slower rate of release after that time. In contrast, large amounts of potassium were released during the drying period following removal of the replaceable bases. A rather slow release of potassium was found after the drying period.

The types of sodium and potassium minerals likely to be found in these soils are believed to account for the difference in the release reactions between sodium and potassium. Sodium release probably is due to a weathering of feldspar minerals, whereas potassium release is from feldspar and micaceous minerals.

Sugar beet yields were increased by sodium chloride fertilization during 1947 and 1948 by an average of about 800 pounds per acre. Sodium plus potassium additions gave increases of 1,200 to 1,600 pounds per acre in 1948. The sugar content of the beets was increased an average of 0.47 per cent in 1948 by both sodium and potassium chloride additions to the soil. The average increase in sugar yields was 360 pounds per acre. These field experiments were conducted on soils containing approximately 0.40 and 0.15 M.E. per 100 grams of replaceable potassium and sodium per acre, respectively.

[1]Doctoral thesis number 963, submitted June 6, 1949.

The order of response to sodium of crops grown in the greenhouse on two widely different soils was garden beets, flax, oats, and corn.

Garden beets responded to sodium in the presence of optimum supplies of available potassium whereas flax and oats appeared to respond only when potassium was deficient. Corn did not respond to sodium under any of the conditions studied. The relative response of beets, oats, and corn to sodium was in the same order as the quantities of sodium absorbed by these crops when grown on soils adequately supplied with sodium.

The amounts of sodium and potassium absorbed by beets and oats varied greatly with the soils studied and with the soil treatments. The sums of sodium and potassium absorbed by oats and beets on different soils which received the same treatment were approximately the same. The sodium content of beets varied between 26 and 161 M.E. per 100 grams, and potassium varied between 17 and 108 M.E. per 100 grams. The sodium content of oat plants varied between 17 and 123 M.E. per 100 grams and potassium between 30 and 108 M.E. per 100 grams.

In oats sodium comprised about 25 per cent of the total bases and in beets about 15 to 20 per cent of the total bases. In contrast, the replaceable sodium contents of the soils on which these plants were grown was less than 1 per cent of the total replaceable bases present.

Sodium additions to the soil had a greater depressing effect on absorption of calcium than magnesium, whereas potassium additions had a greater depressing effect on magnesium than calcium. Potassium showed a greater depression on sodium uptake than sodium on potassium. Combined additions of potassium and sodium depressed magnesium uptake more than calcium, although the differences were not large. In general, better correlations were obtained between the sum of sodium and potassium and yields than between potassium and yields of beets and oats.

The results obtained in this study show that differences in the amounts of available sodium in soils can greatly alter the potassium needs of some crops. Therefore, a consideration of both the replaceable sodium and potassium gives a better indication of the response that can be expected from potassium fertilization, than a consideration of potassium alone.

FISH POPULATION STUDIES ON TWO IOWA RESERVOIRS[1]

WILLIAM MADISON LEWIS

From the Department of Zoology and Entomology
Iowa State College

In an attempt to learn something of the fish populations and their status in the artificial impoundments of southern Iowa, two 80-acre lakes, Red Haw and East Lake, were studied from March 26 to September 22, 1948. These lakes are located in the same valley near Chariton, Iowa, and so situated that overflow water from Red Haw goes directly into East Lake although overflow usually occurs only during the spring rainy season. Some of the more important limnological and physical features of Red Haw are: constructed in 1936, maximum water depth slightly more than 30 feet, exhibits thermal stratification, and has oxygen depletion in the deeper waters during the summer. Similar information on East Lake is as follows: constructed in 1915, maximum water depth 25 feet, thermal stratification not as pronounced as in Red Haw, and has oxygen depletion in the deeper water during the summer. Higher aquatic plants are abundant in both lakes, but the relative abundance of the various species is quite different.

The fish populations were sampled by use of a minnow seine, a bag net, hoop nets, basket traps, gill nets, and angling. The species most abundant in both lakes were: largemouth black bass, bluegill, yellow perch, black crappie, and white crappie. In addition, warmouth were quite abundant in Red Raw, and channel catfish and golden shiner were fairly abundant in East Lake.

To obtain an idea as to what species were most important in support of the fishing pressure, creel censuses were conducted. Creel census data from Red Haw showed the bluegill to be first in importance and the black crappie second. The largemouth black bass catch was relatively poor. The East Lake census data showed the white crappie to be first in importance and the bluegill second. The largemouth black bass and channel catfish catches were poor, but these species rated high from the standpoint of the recreation provided.

The fish specimens collected were weighed, measured, and examined for parasites, and scale samples were taken for age and growth studies. The rate of growth, parasitic infestation, and coefficient of condition, along with some general information, were determined and summarized for the individual species from each lake. With this information comparisons were made between the Red Haw and East Lake fish popula-

[1]Doctoral thesis number 967, submitted June 4, 1949.

tions, and between these and populations which have been studied in other areas.

Three important parasitic infections were found among the fishes of the two lakes. The plerocercoid stage of *Proteocephalus ambloplitis* occurred in large numbers in the ovaries of thirty of the forty female largemouth black bass examined. Metacercaria of *Posthodiplostomum minimum* heavily infested the livers of 255 of the 256 bluegills examined. In addition, this parasite also infested the heart and kidney of all the East Lake bluegills and more than 50 per cent of the Red Haw bluegills. The bluegills of East Lake were much more heavily parasitized than were the Red Haw fish. This difference in degree of parasitism was attributed to the more frequent occurrence of the definitive host, the great blue heron, on East Lake. An epizootic of *Saprolegnia* sp. of approximately two weeks duration occurred in Red Haw during late May and early June. This epizootic was primarily among the larger bluegills and caused a very noticeable mortality. Continuous observations failed to show any similar epizootic in East Lake, probably because of the copper sulfate treatments. In addition to the three more important species of parasites, the following forms also occurred: larval Strigeids, *Clinostomum* sp., leaches, *Argulus* sp., and parasitic copepods of the gills.

A comparison of growth rates showed that the largemouth black bass from East Lake had grown more rapidly than those from Red Haw, and that the bluegills, black crappies, white crappies, and yellow perch from Red Haw had grown more rapidly than those from East Lake. The differences in growth rates of the crappies was quite pronounced, and that of the yellow perch was pronounced after the first year of life. With the exception of the crappies, the differences in growth rates between the fishes of the Red Haw and East Lake were not as great as was anticipated on basis of the suppression of phytoplankton growth in East Lake by the use of copper sulfate.

With the exception of four individuals, all the yellow perch taken from the two lakes were less than 175 millimeters long. It was suggested that this small average size was due to an absence of water with sufficient oxygen and of a temperature suitable for the larger perch.

Although positive age determinations could not be made on the channel catfish, the date of stockings, the number of fish stocked compared to reported yield, and observed yield of excellent specimens in 1948 indicated that this species has a high rate of survival and grows well in East Lake. There was, however, no evidence of natural reproduction.

Age class composition of the various species in the two lakes was somewhat obscured by the selectiveness of the sampling methods, but, nevertheless, a few year classes were outstanding in abundance. The white crappie population of East Lake was composed largely of six-year-old females. The bluegill population of East Lake was dominated by four-year-old fish. The yellow perch population of Red Haw was

made up almost entirely of two-year-old fish, whereas that of East Lake included many more three-year-olds. Yearling black crappies were extremely abundant in Red Haw.

On the basis of the information obtained, the following suggestions for management are made:

1. Maintain and increase the protection from erosion on the watersheds of the lakes.
2. Dredge the shallow water areas of Red Haw to control the excessive growth of higher aquatic plants.
3. Discontinue stocking of bluegills and yellow perch in both lakes.
4. The stocking of bullheads and crappies is of doubtful value.
5. Continue the stocking of largemouth black bass in an effort to overcome the apparent reduction in natural reproduction due to infestation by the bass tapeworm.
6. Continue periodic stocking of channel catfish in East Lake and investigate their use in similar lakes.
7. Further stocking of minnows is not considered profitable.
8. Encourage the harvesting of white crappie from East Lake.
9. Permit year-around fishing for bluegills, crappies, and yellow perch in both lakes.

EFFECT OF MODIFIED CULTURAL PRACTICES ON VERTICILLIUM WILT OF COTTON[1]

PHILIP JORDON LEYENDECKER, JR.

From the Department of Botany, Iowa State College

Verticillium albo-atrum R. and B. is one of the most widely distributed and omnivorous wilt fungi to be found in agricultural soils. It attacks at least 160 species of plants distributed in 40 widely separated families. It is particularly severe on cotton grown in the irrigated regions of the southwestern United States. The American upland commercial varieties (*Gossypium hirsutum* L.) are generally susceptible and little progress has been made in developing resistant varieties.

Since soil temperature and moisture may be regulated in the irrigated regions of the Southwest by use of different types of seed beds, the modification of the environment offers an attractive possibility of controlling the disease. Field and greenhouse experiments designed to study the effect of different cultural practices upon the severity of the disease were conducted at the New Mexico College of Agriculture and Mechanic Arts over a period of three years. The effects of soil moisture and temperature, different crop sequences, and fallow treatment on the severity of disease and quality of fiber have been studied. The results obtained and observations on pathological anatomy are presented.

The field tests were made on soils that had been sown to cotton for a minimum of five years and which were known to be heavily infested with *Verticillium*. Field and greenhouse tests were planted with Acala 2815, a strain of American Upland cotton released by the New Mexico College of A. and M. A.

Soil temperature was increased by modifying the seed bed from the typical flat flood plain to raised beds with furrows between every second row. Three different seed beds were utilized: flat flood with rows 40 inches apart, rows on 8-inch raised beds at 40 inches apart, and rows spaced 28 inches apart on a 15-inch raised bed separated from similar beds by 52 inches. The mean temperature for each of these three types of seed bed during the growing season, April to October, was 21°, 24°, and 28°C. respectively. In each of three years, Verticillium wilt was most severe in the relatively cool (21°C.), flat seed bed, and less prevalent in the 15-inch raised seed bed where the temperature was 7° higher (28°C.). There was a direct correlation between disease control and yields. An association between the severity of disease and reduction in yield was evident in each of the three years.

A number of different irrigation schedules were adopted to deter-

[1] Doctoral thesis number 941, submitted December 13, 1948.

mine their effect on the incidence of cotton wilt. Irrigation water was applied frequently (31 acre inches in seven irrigations), normally (24 acre inches in six irrigations), and infrequently (15 acre inches in four irrigations). The plants in the infrequently watered plots were stunted and often wilted during the heat of midday. However, they had only 32 per cent infection as compared to 48 per cent in the same field when 30 acre inches were added. Unfortunately, the moisture content of the infrequently irrigated plot was too low for satisfactory development of the plants. This injury from drouth was reflected in yield reductions of an average of 400 pounds of seed cotton per acre. There is no economic gain from keeping the plants under aerophytic conditions even though the severity of infection is reduced thereby.

The effect of soil moistures on the disease was determined more precisely under greenhouse conditions. Steamed compost in two-gallon glazed pots was adjusted to 25, 40, 55, 70, and 85 per cent of the water-holding capacity and held at these percentages by the daily addition of water to the soil surface. Plants held at 25 and 40 per cent moisture were stunted and much smaller than those held at 50, 70, and 85 per cent moisture.

Infection was observed over a soil moisture range between 25 and 85 per cent of the water-holding capacity. Practically no foliage injury was observed at 25 and 40 per cent moisture. At 55 and 70 per cent there was progressively more injury showing distinct mottling, necrosis, and abscission of leaves. A slight reduction in disease severity was evident at 85 per cent moisture which undoubtedly was due to limited aeration. The optimum moisture condition for pathogen and host appeared to be too closely related to permit control of the pathogen without retarding the host. Either this reasoning or an assumption that the pathogen invades only rapidly growing plants must be advanced to explain the effect of soil moisture.

The naturally high temperatures and arid conditions which persist in southern New Mexico afford ideal means for the use of fallow to control Verticillium wilt. Therefore a replicated series of irrigated and dry fallow plots was established in a field in which 75 to 85 per cent of the plants had been infected the previous season. It was found that the pathogen did not disappear from soils that were moist and fallowed for one year. However, the severity of infection was reduced appreciably and yields increased by 325 pounds of seed cotton per acre where dry fallow was practiced for a year. *Verticillium* cannot be entirely eradicated from the soil in severely infested fields by dry fallow for a single season. Its prevalence, however, can be reduced to a tolerable level and yields increased materially. Since it is undesirable to allow entire fields to remain idle, a rotation series including one year of fallow might be devised allowing one-fourth or one-half of the land to remain idle in any one season.

The effect of a two-year crop rotation on the severity of Verticillium wilt was determined in a severely infested field by sowing cotton after corn (*Zea mays* L.), hegari (*Sorghum vulgare* Pers.), alfalfa (*Medicago*

sativa L.), sweet clover (*Melilotus officinalis* Lam.), cantaloupes (*Cucumis melo* L.), followed by sour clover (*Melilotus indica* All.), and cotton (*Gossypium hirsutum* L.). The legumes were plowed under as green manure three weeks before seeding to cotton.

Less disease was evident following the cantaloupe-sour clover, sweet clover and alfalfa crops than cotton. There was little, if any, difference between continuous cotton and the plots that had supported corn and hegari the preceding year. Yields following cantaloupe-sour clover cropping were appreciably greater than those following cotton, but, for some unknown reason, yields following sweet clover and alfalfa were reduced somewhat below that following cotton. The latter reductions in yields may have been attributable to fermentations incited by plowing under the green manure before planting cotton. The microorganisms participating in the fermentation process were subsequently in competition with the plant roots for available nutrients.

Material for anatomical studies was collected from naturally infected cotton plants and killed in F.A.A., dehydrated in butyl alcohol, infiltrated with paraffin and cast in Parlax. Embedded material was sectioned, mordanted, and stained with safranin and hemalum.

Verticillium was found to be sparsely distributed throughout the discolored xylem tissue of diseased plants. Contiguous cells of the cambium, phloem, cortex, and pith appeared to be healthy. The mycelial strands were so sparse in the xylem that they had not plugged the vascular tissue. Many of the tracheal tubes, however, were completely plugged with gum-like substances and tyloses. Most of the tracheids remained open and there was evidence that the cambium remained functional and secondary xylem tissue was being produced. The mycelium of the pathogen was most abundant in the tracheal tubes of the fruiting branches, petioles, and leaf veins. Extensive examination of the sectioned material indicated that neither conidia nor microsclerotia were produced by the pathogen in diseased xylem tissue.

In order to determine the effect of the disease on cotton fiber quality, replicated samples were collected from healthy and wilted plants in the same field. Results from spinning and fiber quality tests indicated that the quality of fiber produced on diseased plants was slightly inferior in length, strength, and grade to fiber produced on healthy plants. Yarn spun from fiber from diseased plants was inferior in appearance and strength. The number of neps (breaks) and percentage of manufacturing waste were considerably higher in the samples from diseased plants.

Intensive field surveys disclosed that neither aerial mycelium nor fruiting spores were produced by the pathogen in southern New Mexico. However, isolations of the fungus were made from petioles and main veins of abscissed diseased leaves throughout the growing season. The fungus was also isolated from dry diseased stalks from October 15, 1946, to June 27, 1947, during which time a minimum air temperature of –21°C. was recorded. Since no aerial mycelium or spores could be found, it is likely that the disease is spread primarily by infested plant debris.

REACTIONS OF PHOSPHATE WITH KAOLINITE[1]

PHILIP F. LOW

From the Department of Agronomy
Iowa State College

Kaolinite has been known to fix phosphorus since the latter part of the nineteenth century, but the mechanism or mechanisms whereby the phosphorus is fixed have not been clearly defined. The most popular concept of the reaction of phosphate with kaolinite is that the phosphate reacts with the surface in an anion exchange reaction. Certain observations are not in accord with this theory and so another explanation seems desirable. The hypothesis is advanced that kaolinite dissociates into aluminum and silicate ions and that phosphate precipitates the aluminum ions, thereby disturbing the equilibrium and causing the clay to dissolve in accordance with solubility-product principles.

This hypothesis was tested in several different ways, the first of which was to digest the kaolinite at 45°C. for periods of two and three weeks in phosphate solutions of different concentrations and to analyze the solutions for the silica released and the clay for phosphorus fixed. It was found that the relationship between the silica released and the phosphorus fixed could be represented by two straight lines which intersected at a point corresponding to about 20 millimoles of phosphorus per 100 gm. of clay. The slopes of the two lines indicated that the molar phosphorus fixed-silica released ratios were 0.9 to 1 and 1.8 to 1 for the lesser and greater amounts of phosphorus fixed, respectively. The wide difference in slope between the two lines is regarded as evidence for two different reactions. Since two simultaneous reactions would produce only one line, the conclusion is drawn that the two reactions are not simultaneous.

As a further test of the solubility-product hypothesis, the release of silica by solutions containing different concentrations of 8-hydroxyquinoline and ammonium chloride was determined. Considerably more silica was released to the solution by the former reagent than by the latter. Since 8-hydroxyquinoline precipitates aluminum whereas ammonium chloride does not, the results substantiate the solubility-product hypothesis.

Extraction of phosphorus from the phosphated clay by neutral solutions of various reagents revealed that those reagents capable of forming soluble complexes with aluminum were more effective in extracting the phosphorus than non-complex-forming reagents. In consequence, it is inferred that the phosphorus is combined with aluminum.

Analysis of extraction solutions containing aluminum-complexing reagents (citrate, oxalate, malonate) showed that the relationship

[1] Doctoral thesis number 960, submitted June 7, 1949.

between the quantities of aluminum and phosphorus extracted could be represented by two straight lines intersecting at a point corresponding to about 17 millimoles of phosphorus extracted per 100 gm. of clay. The molar phosphorus extracted: aluminum extracted ratios (P/A1 = 1.2/1 and 1.7/1)were essentially the same as the molar phosphorus fixed: silica released ratios. Moreover, the change in ratios occurred at approximately the same point. Therefore, it may be concluded that the two reactions releasing the silica are responsible for two different aluminum phosphate compounds. As an average of all cases for which data were available the molar silica released: aluminum extracted ratio was the same as the molar silicon to aluminum ratio in the clay; i.e., 1 to 1.

To determine the rates of the reactions between phosphate and kaolinite the phosphate digestion solutions were analyzed for silica at intervals over a period of five weeks. The time-rate of silica release corroborated previous evidence in that two different reactions occurred, the first reaction being a typical adsorption reaction which was faster in its initial stages than the second reaction. The maximum value in the first reaction was reached at approximately 24 millimoles of silica released per 100 gm. of clay. Since preceding experiments had shown that the amount of silica released in this reaction is equivalent to the phosphorus fixed, the conclusion is drawn that this adsorption reaction is a replacement of surface-exposed silicon tetrahedra by phosphorus tetrahedra. If this is the correct interpretation of the data, the surface phosphate in the first reaction should be unstable because the type of combination visualized would involve an infraction of the electrostatic valence rule.

The second reaction was a linear function of time and did not begin until the adsorption reaction was completed. The constant rate of silica release during this reaction is considered as being evidence for the dissolution of the clay. Equations representing the solution of crystals support the hypothesis. The fact that the second reaction did not begin until the first reaction was completed indicates that the second reaction is dependent on the first. The proposal is made, therefore, that when near-saturation of the surface is reached, the unstable surface phosphate begins to dissolve away under the influence of the phosphate in solution and a more stable phosphate with a higher phosphorus content is formed. As fresh surface becomes exposed it reacts with the phosphate in solution and the process is repeated. In this manner phosphatolysis of the clay is accomplished.

A similar experiment on the time-rate of phosphorus extraction, using potassium citrate as extractant, was set up. The results showed that there were two different rates of extraction; 23 millimoles of phosphorus per 100 gm. of clay were extracted the first day and the remainder of the phosphorus was extracted in small increments as a linear function of time over the following four-day period. Since the previous experiments indicated that about 17 to 24 millimoles of phosphorus per 100 gm. of clay were fixed on the surface, the conclusion is drawn that the

phosphorus extracted the first day represents the surface phosphorus. The rapid extraction of the surface compound is taken as evidence for its relative instability. The linear extraction rate of the second compound is regarded as evidence for a constant dissolving surface exposed by this compound; therefore, the compound is believed to be present as a thin film on the more inert surfaces of the clay.

To investigate the possibility of phosphate adsorption from dilute phosphate solutions kaolinite was shaken for one and one-half hours with phosphate solutions in concentrations less than 0.05 mgm. of P per ml. The resulting adsorption curve obeyed the Freundlich equation. Obedience to this equation suggests that an anion exchange occurs and that equilibrium between the clay and the solution is reached very rapidly. The leveling-off of the curve after small quantities of phosphorus had been adsorbed indicates that this adsorption is not silicate replacement; phosphate exchange for hydroxyl groups on the surface of the clay is regarded as being more likely. The hydroxyl-exchange theory is substantiated by evidence that the adsorption is chemical in nature, as indicated by increasing phosphate adsorption with increasing temperature. That hydrous aluminum oxide may be the exchange medium was shown by the production of a reddish hue on the surface of the clay when it was shaken with an aqueous solution of ammonium aurintricarboxylate. The aurintricarboxylate ion forms a red chelate-ring complex with aluminum.

A PIEZOMETER METHOD OF MEASURING SOIL PERMEABILITY AND APPLICATION OF PERMEABILITY DATA TO A DRAINAGE PROBLEM[1]

James Nicholas Luthin

From the Department of Agronomy
Iowa State College

A field method of measuring the soil permeability beneath a water table has been developed. Pipes of small diameter (called piezometers) were driven into the soil below the water table, the soil was augered out of the piezometers and the rate of inflow of the water from the soil into the piezometer was measured. A special technique was developed to minimize soil compression and puddling when the piezometers were driven into the soil. A hole was augered out to a depth of about 6 inches below the surface of the soil. The auger used was one of 1/10 inch smaller diameter than the inside of the piezometer. The piezometer was then driven into the augered-out hole about five inches. The auger was inserted inside of the piezometer and a cavity augered out for another six inches below the end of the piezometer which was then driven into the soil for another five inches. This procedure of successive augerings was repeated until the piezometer was at the desired depth below the soil surface. A cavity of any convenient length was augered out beneath the end of the piezometer and the water was pumped out of the cavity. The rate of inflow of the water into the pipe was measured.

The permeability was then calculated by means of a suitable equation developed by Kirkham. A certain term which depends on the geometry of the system occurs in Kirkham's equation. This term was called the *A*-function and was evaluated by means of a three-dimensional electric analogue. In addition the electric analogue was used to study the effect of rocks and worm holes on the permeability determination. Their effect was found to be small.

Field tests of the piezometer method of permeability measurement were made on several Iowa soils with satisfactory results.

Of the various methods of obtaining solutions for the drainage problem, the numerical analysis procedure is the one capable of application to the widest variety of problems with a minimum of skill and labor. The problem of the drainage of a uniform soil was solved numerically and the answer compared to Kirkham's analytical solution. The error of the numerical solution was less than 4 per cent.

The tile drainage of the two-layered soil with the trench backfilled with surface soil was studied by numerical analysis for various

[1] Doctoral thesis number 970, submitted June 6, 1949.

ratios of permeability of surface soil to subsoil. The study showed that in a soil with two feet of surface soil having five or more times the permeability of the subsoil, tiles were almost as effective when placed at a depth of two feet as when placed in the bottom of a four foot trench backfilled with surface soil.

CLEAVAGE AND SUBSTITUTION REACTIONS OF SOME ORGANOSILANES[1]

FREDERICK JOSEPH MARSHALL

From the Department of Chemistry,
Iowa State College

Cleavage of carbon-metal bonds by hydrogen chloride is characteristic of organometallic compounds. Organosilicon compounds have been the subject of very little such investigation. Thus, it was the primary purpose of this thesis to determine the extent to which these compounds undergo this cleavage. If the reaction were shown to be general, silicon could, in this sense at least, be considered metallic. At the same time the agreement with the previously established series of radicals in the order of the ease of their removal from metals, such as lead, mercury, and tin, could be determined. Another purpose was to investigate the applicability of certain substitution reactions to organosilanes to obtain compounds containing functional groups.

Hydrogen chloride cleavage of triphenylarylsilanes in refluxing glacial acetic acid presented difficulty in isolating the silicon-containing fragment. This was apparently due to further cleavage after the dissimilar group was removed. Triphenyl-*p*-anisylsilane gave 41 per cent of anisole and 1.7 per cent of triphenylsilanol; the only cleavage product isolated from triphenyl-2-thienylsilane was 12.7 per cent of triphenylsilanol; and triphenyl-*p*-dimethylaminophenylsilane yielded 76 per cent of dimethylaniline and 2.3 per cent of triphenylsilanol. Cleavage of triphenylsilanol itself gave an 82 per cent yield of benzene based on the removal of two phenyl groups, no silicon portion being isolated. Tetra-*o*-tolyldisilanediol gave a quantitative yield of silica and 43 per cent of toluene.

When alkyl-arylsilanes were cleaved, ethyltriphenylsilane and diethyldiphenylsilane yielded, respectively, 44 per cent and 68 per cent of benzene. In neither case was the silicon fragment isolated. This difficulty could be obviated by the use of compounds in which only one group would be removed. Tri-*n*-butylphenylsilane (b.p., 116°–118°/0.9 mm.) yielded 24 per cent of tri-*n*-butylsilanol (b.p., 81°–83°/0.45 mm.), 71 per cent of hexa-*n*-butyldisiloxane (b.p., 136°–138°/0.5 mm.), and 68 per cent of benzene. Tribenzyl-*p*-anisylsilane (m.p., 83°–85°) gave 79 per cent of tribenzylsilanol and 84 per cent of anisole.

The trimethylarylsilanes are admirably suited for these studies because the methyl groups are not cleaved and the course of the reaction can be traced by the amount of trimethylsilyl chloride produced. The results of these cleavages are listed in Table 1.

On the basis of these findings the rate of cleavage of radicals is

[1] Doctoral thesis number 924, submitted July 16, 1948.

2-thienyl > *p*-anisyl and *p*-dimethylaminophenyl > *p*-tolyl > phenyl > *p*-chlorophenyl > benzyl and β-phenylethyl. This is in essential agreement with the previous results obtained with organomercury and organolead compounds.

Attempted nitration and chloromethylation of tri-*n*-butylphenylsilane gave, respectively, 58 per cent and 88 per cent recoveries of starting material. Triphenyl-*p*-tolylsilane was converted to triphenyl-*p*-dicloromethylphenylsilane by treatment with sulfuryl chloride. The yield of

TABLE 1

HYDROGEN CHLORIDE CLEAVAGES OF TRIMETHYLARYL- AND ARALKYLSILANES

$(CH_3)_3SiR$, *R*	Reaction Time	Yield of Cleavage Products $(CH_3)_3SiCl$	RH
	(hours)	*(per cent)*	
2-Thienyl	1	87.0	37.0
p-Anisyl	1	69.5	76.0
p-Dimethylaminophenyl*	1	67.0	73.5
p-Tolyl†	1	53.5	62.0
Phenyl	6	70.0	60.0
p-Chlorophenyl	6	43.0	48.0
Benzyl	15	....	....
β-Phenylethyl‡	15	....	....

* B.p. 252°–253°.
† B.p. 192°.
‡ B.p. 211°.

product, melting at 167°–169.5°, was 27 per cent of the theoretical. Attempted hydrolysis of the dichloro compound to the corresponding aldehyde was unsuccessful.

The second portion of the thesis was concerned with the synthesis of quinoline derivatives for testing as potential antimalarial compounds. 2-Phenyl-6-methoxyquinoline-4-aldehyde (m.p. 136.5°–137.5°) was prepared by selenium dioxide oxidation of the corresponding 4-methyl derivative. Reaction between the aldehyde and phenylmagnesium bromide gave α-phenyl-6-methoxy-2-phenyl-4-quinolinemethanol hydrochloride (m.p., 227°–232°). α-Phenyl-4-quinolinemethanol hydrochloride (m.p., 194°–199°) was prepared in the same manner from quinoline-4-aldehyde (2).

Attempted preparation of 6-quinolyl methyl sulfide from *p*-acetaminophenyl methyl sulfide gave a small amount of an impure oil (b.p., 103°–105°/0.2 mm.). The presence of at least some of the desired product was shown by preparation of the picrate (m.p., 214°–216°) and by potassium permanganate oxidation to the known 6-quinolyl methyl sulfone (1). Similarly, the attempted preparation of 6-quinolyl methyl sulfoxide from *p*-acetaminophenyl methyl sulfoxide yielded only a tarry

product. That some of the product was formed was shown by isolation of some of the sulfone after oxidation as above.

8-(2,5-Dimethylpyrryl-1)-6-quinolyl methyl sulfone (m.p., 184°–186°) was prepared by condensation of the 8-amino compound (1) with acetonylacetone.

The thesis also contains a survey of the literature on the cleavage of organometallic compounds.

LITERATURE CITED

1. Gilman and Lindblad
1946. Jour. Amer. Chem. Soc. 68, 982.

2. Kaplan
1941. Jour. Amer. Chem. Soc. 63, 2,654.

SYNTHESIS OF SOME VALINE DERIVATIVES AS POTENTIAL ANTIBACTERIAL AGENTS *

FREDERICK MINARD

From the Department of Chemistry
Iowa State College

Among the characteristics of many peptide-like antibiotics are the presence of D-amino acids and a specific structure. A number of acylated valines were prepared for bacteriological testing. Because previous work has indicated (1, 2) that the mere inclusion or repetition of the D configuration in amino acid derivatives is not enough to confer antibiotic activity, emphasis was placed upon the finding of active acyl groups prior to the study of the effect of optical isomerism.

An amino acid derivative having unusual bond distances or angles might possibly interfere with enzyme-substrate complex formation and thus interfere with bacterial metabolism. For this reason the following cyclobutane derivatives were prepared: *cis*-1,2-cyclobutanedicarbonyl-DL-valine, melting point 102.5°–103.5°, monohydrate, melting point 80°–83°, *cis*-1,2-cyclobutanedicarbonyl-D-valine monohydrate, melting point 92°–98°, $[\alpha]_D^{26}$ +77.5°,† *cis*-1,2-cyclobutanedicarbonyl-L-valine monohydrate, melting point 92°–98°, $[\alpha]_D^{26}$ —76.1°, *cis*-2-carboxycyclobutanecarbonyl-DL-valine, melting point 178°–179°, *cis*-2-carboxycyclobutanecarbonyl-D-valine, melting point 168°–169°, $[\alpha]_D^{27}$ +7.4°, *cis*-2-carboxycyclobutanecarbonyl-L-valine, melting point 168°–169°, $[\alpha]_D^{26}$ —7.2°. The corresponding benzene derivatives were also prepared: phthaloyl-DL-valine, melting point 102°–103°, monohydrate, melting point 80.0°–81.5°, *o*-carboxybenzoyl-DL-valine, melting point 171.5°–172.0°, *o*-carboxybenzoyl-D-valine, melting point 153°–154°, $[\alpha]_D^{27}$ +16.2°, *o*-carboxybenzoyl-L-valine, melting point 154°–155°, $[\alpha]_D^{24}$ -15.9°. The amidic acids were obtained by a mild alkaline hydrolysis of the imides, which were prepared by fusion of a form of valine with either *cis*-1,2-cyclobutanedicarboxylic anhydride or phthalic anhydride.

Various acylated valines were prepared which contain an ethylenic α, β to a carbonyl group. There are clear indications that such activitated ethylenic linkages can inactivate certain enzymes by adding their sulfhydryl groups. Fumaryl-di-DL-valine, melting point 282°–283°, was

*Doctoral thesis number 971, submitted June 6, 1949.

†All rotations were taken on 3 per cent solutions in absolute ethanol except those taken on the maleyl derivatives which were 3 per cent solutions in ethyl acetate.

prepared by the reaction of fumaryl chloride with DL-valine in alkaline medium. The action of maleic anhydride on the three forms of valine gave maleyl-DL-valine, melting point 166°–167°, maleyl-D-valine, melting point 132°–133°, $[\alpha]_D^{21}$ —26.2°, maleyl-L-valine, melting point 132°–133°, $[\alpha]_D^{21}$ +25.5°. Treatment of methyl-DL-valinate with itaconic anhydride gave methyl itaconyl-DL-valinate, melting point 88°–89°, which upon mild alkaline hydrolysis gave itaconyl-DL-valine, melting point 139°–140°.

Because of the gross similarity of the acid to the ring structure of penicillin, the acid chloride of 2-carboxy-4-hydroxy-*trans*-3,6-endomethylenehexahydrobenzoic acid γ-lactone was coupled with DL-valine in alkaline medium to give 2-carboxy-4-hydroxy-*trans*-3,6-endomethylenehexahydrobenzoyl-DL-valine γ-lactone, melting point 230°–231°. The acid chloride of the isomeric *cis*-lactonic acid was coupled with methyl DL-valinate to give a methyl ester, melting point 168°–169°, which was hydrolyzed to 2-carboxy-4-hydroxy-*cis*-endomethylenehexahydrobenzoyl-DL-valine γ-lactone, melting point 191.5°–192.5°. Fusion of *endo-cis*-3,6-endomethylene-Δ^4-tetrahydrophthalic anhydride with DL and D-valine gave respectively *endo-cis*-3,6-endomethylene-Δ^4-tetrahydrophthaloyl-DL-valine, melting point 118°–119°, and the *endo-cis*-3,6-endomethylene-Δ^4-tetrahydrophthaloyl-D-valine, melting point 116°–117°, $[\alpha]_D^{24}$ +60.4°.

The following new compounds were prepared in the manner indicated: DL-valine methyl ester hydrochloride, melting point 90°–97°, by a Fischer esterification; benzoyl-DL-valine methyl ester melting point 90°–91°, by a Fischer esterification; DL-valine *n*-butyl ester sulfate, melting point 140.5°–141.5°, by addition of the ester to sulfuric acid in ether; *N*-(*n*-butyl)-phthalamic acid, melting point 107.5°–108.5°, by hydrolysis of the imide; *cis*-1,2-cyclobutanedicarboxamic acid, melting point 159°–159.5°, by action of ammonia on the anhydride; *endo-cis*-3,6-endomethylene-Δ^4-tetrahydrophthalanilic acid, melting point 135°–145°, by action of aniline on the anhydride; and 2-carboxy-4-hydroxy-*cis*-3,6-endomethylenehexahydrobenzanilide γ-lactone, melting point 232°–233°, by fusion of the acid with aniline or treatment of the acid chloride with aniline.

Attempts to resolve DL-valine by the papain-catalyzed precipitation of acylated-L-valinanilides were unsuccessful from a practical viewpoint. Benzoyl-DL-valine gave a 4 per cent yield of benzoyl-L-valinanilide; formyl-, acetyl-, and phthaloyl-DL-valine gave no detectable amount of anilide.

It was found that upon treatment of a phthalamic acid with aniline in a citrate buffer at 40° for several days *N*-phenylphthalimide precipitated out. The following acids were tested: phthalamic acid, *N*-butylphthalamic acid, *N*-phenylphthalamic acid, and *o*-carboxybenzoyl-DL-valine. This reaction may possibly be of interest as a type of *in vitro* peptide bond synthesis.

LITERATURE CITED

1. Fling
1946. Doctoral thesis, No. 802. (Unpublished). Library, Iowa State College.

2. Fox, Kobayashi, Melvin, and Minard
1948. Jour. Amer. Chem. Soc. 70, 2404.

THE DISTRIBUTION OF CERTAIN AMINO ACIDS IN THE SOLUBLE NITROGEN FRACTION OF MILK CULTURES OF *STREPTOCOCCUS LACTIS*[1]

MAX E. MORGAN

From the Department of Dairy Industry, Iowa State College

The literature contains numerous reports ascribing to *S. lactis* slight proteolytic action as determined by increases in soluble nitrogen in milk cultures. These reports indicate that the breakdown is carried to the amino acid stage but no information has been available regarding the extent to which the various amino acids are liberated from milk proteins.

In the present work microbiological assays for ten amino acids (valine, leucine, isoleucine, threonine, arginine, methionine, histidine, tryptophan, tyrosine and phenylalanine) were performed on protein-free filtrates prepared from fifteen-day skim milk cultures of several strains of *S. lactis* incubated at 21°C. The filtrates tested were prepared by two methods. One portion of each culture was diluted and treated with H_2SO_4 and Na_2WO_4 solutions to give a final concentration of 0.7 per cent H_2WO_4 at a *p*H of 2.4 to 2.5. The resulting precipitate was removed by filtering through Whatman No. 2 filter paper. A second aliquot of each culture was diluted and heated in a boiling water bath for five minutes, cooled and the acid- and heat-coaguable proteins removed by filtration. Comparable filtrates were prepared from a sterile control sample of skim milk which was adjusted with lactic acid to the same *p*H as the milk cultures before heating. All filtrates were adjusted to *p*H 7.0 and made to the appropriate dilutions prior to assay. The assay method for all ten amino acids was that described by Stokes and coworkers (1). *Lactobacillus delbrueckii* LD5 (ATCC #9595) was used for the determination of tryosine and phenylalanine and *Streptococcus faecalis* (ATCC #9790) was employed for the other eight amino acids.

The individual amino acid values for both filtrates of all strains revealed marked increases over the values for filtrates of the uninoculated control. There was considerable variation in the proteolytic activity among the strains tested. Higher values were obtained on the lactic acid filtrates than on the tungstic acid filtrates in every case. This was believed to be due to the presence of a higher proportion of the lower fractions of protein degradation which possess amino acid activity for the assay organisms employed.

[1] Doctoral thesis number 925, submitted July 26, 1948.

The amino acid activity of the tungstic acid filtrates varied with the different amino acids, and it was noted that the proteolytic enzymes of *S. lactis* liberate free amino acids and small degradation fractions possessing amino acid activity in approximately the same proportion as the individual amino acids occur in milk proteins.

In a second experiment, unhydrolyzed tungstic and lactic acid filtrates were prepared from skim milk cultures of two strains of *S. lactis* possessing different degrees of proteolytic acitivity. These cultures were incubated at 21°C. for one, three, seven, and fourteen days. The hydrolyzed filtrates were prepared by treating tungstic and lactic acid filtrates with H_2SO_4 (filtrates made 2N) and autoclaving for five hours. The excess sulfate was removed with $Ba(OH)_2$.

Assays for leucine and phenylalanine on the unhydrolyzed tungstic and lactic acid filtrates indicated that active strains of *S. lactis* are able to effect a marked increase in the free amino acids and/or peptides possessing amino acid activity during the first three days of incubation. The rate of increase was somewhat more rapid with the lactic acid filtrates, indicating that protein degradation products possessing amino acid activity and insoluble in tungstic acid were being liberated. The rate of increase declined after the third day, and there was a slower but continued increase through the fourteenth day. Simultaneous although not parallel increases in the assay values of the hydrolyzed lactic acid filtrates indicated that the total concentration of protein degradation products increased during the fourteen-day incubation period. The assay values for leucine on the hydrolyzed tungstic acid filtrates were slightly higher than those for the unhydrolyzed tungstic acid filtrates throughout the incubation period, indicating that tungstic acid did not remove all of the leucine in peptide form from the milk cultures.

The high leucine activity of a hydrolyzed lactic acid filtrate of sterile skim milk as compared to the relatively low activity of the unhydrolyzed filtrate indicated the presence of an intermediate fraction which probably was proteose or peptone in nature. This fraction contained very little phenylalanine.

Throughout this work the assays for phenylalanine on unhydrolyzed lactic acid filtrates revealed a marked upward drift with each increment of added filtrate. Since this drift was not evident in phenylalanine assays of the other filtrates, it was concluded that *S. lactis* milk cultures contain a factor stimulatory for *L. delbrueckii* LD5 which is not coaguable by either heat or acid but is insoluble in tungstic acid and is destroyed by acid hydrolysis.

The data presented appear to be applicable to further explanation of the role of *S. lactis* in the ripening of Cheddar cheese. Even though the *S. lactis* cells in cheese die off during the early stages of ripening, their proteolytic enzymes may continue active. The amino acids and smaller fractions of protein degradation provided by the early action

of the proteolytic enzymes of *S. lactis* on the cheese protein apparently provide the necessary stimulus for development of the lactobacilli.

LITERATURE CITED

1. Stokes, J. L., M. Gunness, I. M. Dwyer, and M. C. Caswell
1945. Microbiological methods for the determination of amino acids. II. A uniform assay method for the ten essential amino acids. Jour. Biol. Chem. 160:35–49.

TECHNIQUE FOR TESTING THE HOMOGENEITY OF SEPARATELY-EVALUATED BEHAVIOR CHARACTERISTICS[1]

CHARLES OWEN NEIDT

From the Department of Vocational Education
Iowa State College

When scores on psychological tests are obtained by combining numerical values assigned to individual test items, consideration must be given to the homogeneity of performance upon the component parts of the tests.

In educational evaluation the extent to which each objective must be subdivided before appraisal of instruction can be undertaken must also be considered. The testing of homogeneity among differing educational objectives is also appropriate as well as the determination of differences in behavior elicited by differing types of tests involving the same course material.

To fulfill the need for testing the homogeneity of separately-evaluated behavior characteristics, two formulas were developed. The first formula, *F*-test for significance of departure from homogeneity, was proposed to evaluate the null hypothesis: There is no significant difference in the reactions of individuals to test items among areas of the test than to test items within the areas of a test.

The formula is

$$F = \frac{1 + \bar{r}_W - 2\bar{r}_A}{1 - \bar{r}_w}$$

where $\bar{r}_w$ = average intra-area (odd-even) coefficient of correlation and $\bar{r}_A$ = average inter-area coefficient of correlation and both averages are obtained with the use of the function

$$1/2 \log_e \frac{1+r}{1-r}.$$

The degrees of freedom for determining the significance of the *F*-value are $(N-1)$ $(k-1)$ and $(N-1)$, where N = number of subjects and k = number of areas in the test.

The second formula, a correction for attenuation, was proposed as a positive indication of homogeneity. The formula is

$$r_{00} = \sqrt{1 - \bar{r}^2_W + \bar{r}^2_A}$$

where the notation is the same as for the foregoing formula.

[1] Doctoral thesis number 964, submitted June 7, 1949.

To justify the use of the proposed formula for correction for attenuation and to compare the efficiency of correction of the proposed formula with the efficiency of four previously-developed formulas for correction for attentuation, three empirical demonstrations were designed.

In the first demonstration two perfectly-correlated hypothetical distributions of 20 values each were designated. These distributions were identified as "$Basic_1$" and "$Basic_2$." Four "test forms" were then developed, two from "$Basic_1$" and two from "$Basic_2$" by varying the size of the values in the basic distributions 0 or 1 at random. Thus the true correlation was reduced from unity only because of the presence of "variable errors." This procedure was repeated ten times so as to result in ten applications of the formulas to four sets of test forms of 20 values and one application to a combined set of four test forms of 200 values. The five formulas for correction for attenuation under consideration were then applied. All formulas were found to be equally satisfactory in removing the effect of variable errors in the case of approximately equal means and variances in the test forms.

In the second demonstration the two test forms developed from "$Basic_1$" were obtained in the same manner as in the first demonstration. The two test forms developed from "$Basic_2$," however, were obtained by varying the basic distribution 0 to 9 at random. Thus one pair of test forms had a high correlation, or reliability, and the other a considerably lower correlation. As in the foregoing demonstration the procedure was repeated ten times. Because of a negative correlation in one of the ten sets of four test forms, all but the proposed formula were inappropriate for that set of four test forms. Although the true correlation in this demonstration is less than unity, all but the proposed formula yielded estimates of the true correlation higher than unity in one or more of the eleven applications. Estimates of the true correlation obtained with the use of the proposed formula were also more uniform than estimates obtained with the use of any one of the other four formulas.

In the third demonstration unlike basic distributions of 20 values each were used from which to develop the test forms. This procedure resulted in greater variability in the test forms than in either of the two preceding demonstrations. Again ten sets of four test forms based on 20 values and a combined set of four test forms based on 200 values were used. Estimates of the true correlation were obtained by applying the five formulas for correction for attenuation. A negative correlation in one of the sets of test forms rendered the four previously-existing formulas inappropriate for that set of test forms. As in the second demonstration, all except the proposed formula yielded estimates greater than unity in some cases. Greater variability among the estimates obtained with the use of the four previously existing formulas was noted than among the estimates obtained with the proposed formula.

To demonstrate the use of the formula for testing the significance

of departure from homogeneity and the proposed formula for correction for attenuation, several actual test situations were selected. The two formulas were applied to the results of an aptitude test, an interest test, and an attitude test. Achievement testing was divided into a test situation involving a single course objective, one involving several course objectives each covered by one or more separate tests, and objective and essay types of a test involving the same course material.

Each test situation was chosen because of its appropriateness and emphasis was placed upon demonstrating the techniques rather than upon investigating the characteristics of the specific tests used.

It was found that the quantitative and linguistic areas of the American Council on Education Psychological Examination for College Freshmen elicited different types of behavior from a sample of fifty college freshmen.

The two areas of a scale to measure interest in farming, i.e., farming as a vocation and farming as a way of life, were found to elicit homogeneous behavior from fifty high school seniors.

Applying the technique to seven areas of the Fritz Test of Cynicism, it was found that 400 college students reflected nonhomogeneous behavior in the cynical attitudes they expressed toward politics, labor, religion, marriage, education, and wealth.

In a test involving recall of information concerning four areas of conservation, i.e., wild life, forests, water, and soils, homogeneous behavior was reflected among these four areas when forty-eight ninth-grade pupils were used as subjects.

When the formulas were applied to tests covering three objectives in a course in elementary statistics, recall of information, interpretation of statistical inference, and computation, nonhomogeneous behavior was found. This group included only twenty-two graduate students as subjects, however.

Objective and essay-types of a test involving ability to apply generalizations concerning color and recall of color information were given to fifty ninth-grade home economics students. When the formulas were applied to the types of test concerned, it was found that the behavior elicited by the two areas of the objective test was homogeneous, whereas the behavior elicited by the two areas when the test was administered in essay form was nonhomogeneous.

In view of the results from applying the technique for testing the homogeneity of separately-evaluated behavior characteristics to hypothetical and actual test situations in this investigation, the technique is proposed for use in psychological testing and educational evaluation.

PURIFICATION AND CHARACTERIZATION OF MACERANS AMYLASE[1]

ETHELDA NORBERG

From the Department of Chemistry, Iowa State College

Schardinger dextrins are produced from starch by the action of macerans amylase, an enzyme elaborated by *Bacillus macerans*. These dextrins have been shown to have a cyclic structure in which six or more glucose residues are joined together by α-1,4-glucosidic bonds (1). The formation of these dextrins has been attributed to a type of "glucosidic exchange" action in which a glycosidic bond in the substrate chain is exchanged for a glycosidic bond in the cyclic dextrin molecule (2). This mechanism could not account for any hydrolytic action shown by macerans amylase on its glucosidic substrates.

In these studies macerans amylase has been prepared practically free from hydrolytic activity. It has been shown that this activity decreases with increased purification, and that it can be preferentially inactivated by heating purified enzyme preparations. Hydrolytic activity in preparations of macerans amylase, then, has been attributed to the presence of an *alpha*-type amylase impurity.

The enzyme purification procedure developed here includes alcohol precipitation, at —10°C. to 0°C., adsorption on starch from 25 per cent acetone solution, elution with *beta* dextrin solution, pervaporation, and dialysis. This gives an enzyme solution which assays 641 units per mg. protein (based on nitrogen analysis). An additional adsorption on starch gives a preparation which shows 1.4 per cent hydrolysis of starch after 500 conversion periods. This compares favorably with the purest preparation reported in the literature by McClenahan, Tilden, and Hudson (3), which assays 30 units per mg. of solids and shows 1.6 per cent hydrolysis of starch after 100 conversion periods.

Studies on the mode of action of macerans amylase have been facilitated by development of methods for qualitative analysis of enzymolysate mixtures. A procedure for analysis of mixtures of reducing oligisaccharides has been developed, based on hypoiodite oxidation and electrophoretic analysis of the corresponding acid anions. Schardinger dextrin mixtures have been resolved electrophoretically in iodide solution.

With these analytical methods, the course of macerans amylase action on definable substrates has been followed. It has been shown that Schardinger dextrin formation is only one aspect of the glucosidic

[1]Doctoral thesis number 962, submitted June 6, 1949.

exchange action of macerans amylase. A general redistribution reaction is also effected among the linear substrate molecules. Thus, a straight chain heptasaccharide substrate was converted to a mixture of Schardinger dextrins, glucose, maltose, trisaccharide, tetrasaccharide, and higher saccharides. Results seemed to indicate that the initial reactions were those of equations (1) and (2):

(1) $2G_7 \longrightarrow G_4 + G_{10}$

(2) $G_{10} \longrightarrow G_4 + \alpha$

Successive stages of macerans amylase action on heptasaccharide, as determined by electrophoretic analysis, may be represented as in (3):

(3) $G_7 \longrightarrow G_4 + G_7 + G_{10} + \alpha \longrightarrow$
$G + G_2 + G_3 + G_4 +$ higher saccharides $+ \beta$.

Coupling reactions between cyclic dextrins and linear cosubstrates have previously been shown to be evidences of the reversal of Schardinger dextrin formation (4). These studies have shown that redistribution reactions, Schardinger dextrin formation, and coupling reactions can occur simultaneously to effect an approach to the equilibrium composition for any given substrate. Macerans amylase action on comparable digests of heptasaccharide, *alpha* dextrin plus glucose, and *beta* dextrin plus maltose has been followed by reducing value determinations and electrophoretic analysis of digest components. Each digest was equimolar in reducing groups and contained the same total carbohydrate concentration. It was shown that the same equilibrium was approached in each enzymolysis.

Macerans amylase specificity was also shown to include a pure maltose substrate. This was converted to a mixture of glucose, maltose, trisaccharide, tetrasaccharide, and some higher saccharides. However, relative reaction rates with heptasaccharide and maltose substrates indicated that the enzyme affinity was greatest for the inner linkages of longer chain dextrins.

Beta-amylase limit dextrin was attacked by macerans amylase to produce a rapid decrease in viscosity and a change of iodine coloration from lavender to brown. Since no appreciable amount of Schardinger dextrins could be detected after this action, it has been suggested that branched cyclic dextrins may be formed.

In general, the picture of macerans amylase action presented by these studies offers explanation for the previously observed stages in its action on starch: i.e. liquefaction, dextrinization, and slow saccharification. The development of a procedure for preparation of larger quantities of a purified enzyme should permit further characterization of the macerans amylase protein. More quantitative measurements of macerans amylase action may now be interpreted in view of the qualitative picture of dynamic equilibrium presented here.

LITERATURE CITED

1. French and Rundle
1942. Jour. Amer. Chem. Soc. 64, 1651.

2. Cori
1945. Federation Proc. 4, 226.

3. McClenahan, Tilden, and Hudson
1942. Jour. Amer. Chem. Soc. 64, 2139.

4. French, Pazur, Levine, and Norberg
1948. Jour. Amer. Chem. Soc. 70, 3145.

THE EFFECTS OF CONCENTRATION POLARIZATION ON ELECTRODEPOSITION WITH CONTROLLED CATHODE POTENTIAL[1]

EUGENE MERRIDITH SALLEE

From the Department of Chemistry, Iowa State College

Chemical analysis by electrodeposition is normally accomplished by passing a current between inert electrodes in a solution containing metal ions and weighing the metal deposited on the cathode. The cathode-solution potential depends on the activity of the metal ions in solution as well as the equilibrium potential, and as the concentration of metal in solution is reduced the potential will rise. To prevent the discharge of other metals present or of hydrogen it is necessary to limit the cathode-solution potential by reducing the applied voltage during a deposition. Caldwell, Parker, and Diehl[2] recently described an apparatus which automatically limits the cathode-solution potential during an electrolysis. To use such an apparatus it is necessary to determine the proper limiting potential for given conditions. This potential depends on the reversible potential and on the concentration polarization. In order to calculate the value at which to limit the cathode-solution potential for electrolytic separations of metals it is necessary to determine the magnitude of this concentration polarization.

A study of the reversible potentials and of the concentration polarization was made using copper in chloride solutions. During the electrolysis of copper in chloride solutions the copper is first reduced to the univalent state which forms a stable chlorocuprous ion, $CuCl_3^=$, and the deposition reaction is the reduction of univalent copper. Working in a nitrogen atmosphere the potentials between metallic copper and various cuprous chloride solutions were determined. For a given constant chloride concentration between 0.5 and 2.25 molar, the equilibrium potentials followed Nernst's equation at least down to 5×10^{-4} molar total copper, but metallic copper rapidly dissolved in chloride solutions containing little or no copper. By tracing the time-potential curves for copper in chloride solutions it was found that both the shape of the curves and final equilibrium potentials depended on the prior treatment of the copper surface to a greater extent than on the chloride concentrations. When the change of copper concentration was followed with radioactive copper it was shown that the potential did not depend on the copper concentration in very dilute solutions and hence that indicator electrodes of the metal being deposited cannot give a measure of the concentration of metal ions near the end of a deposition.

[1] Doctoral thesis number 917, submitted June 28, 1948.
[2] Caldwell, Parker, and Diehl. Ind. Eng. Chem., Anal. Ed., 16, 532-35 (1944).

By plotting current-potential curves and extrapolating to zero current, concentration polarization was shown to be less than ten millivolts for the solutions used at current densities of less than three-tenths milliamperes per square centimeter. Since lower current densities than this are used at the end of electrolysis with controlled cathode potential, concentration polarization had little effect on the limiting potential. The plateau shown by the current density-potential curves for copper in chloride solutions apparently indicated considerable concentration polarization, but was explained as being due to the simultaneous deposition of hydrogen and copper. Deposits made at higher and lower current densities than this plateau showed no difference in crystal structure when examined with a microscope and an electron microscope.

To calculate the limiting potential for a deposition it was shown to be necessary only to specify the chloride ion concentration and the total residual copper after electrolysis and add ten millivolts for concentration polarization. Reasonable variations in the concentration of chloride and in the total volume did not affect the limiting potential for carrying out a determination.

An exchange between metallic copper and cuprous copper in chloride solutions was established using radioactive copper.

FACTORS INFLUENCING THE THIAMINE REQUIREMENT OF THE CHICK[1]

PAUL E. SANFORD

From the Department of Poultry Husbandry
Iowa State College

Considerable work has been done in recent years concerning the fact that certain fish products contain a factor or factors which interfere with thiamine utilization. Observations of polyneuritis in chicks and Chastek paralysis in foxes, minks, and cats have been reported when fresh fish tissues were fed. The present work was undertaken to study: (1) the seriousness of this problem in commercial fish products in common use in poultry diets, (2) the effects of feeding various vegetable protein sources and feeding a diet composed of three sources of supplementary protein upon the thiamine requirement and growth of the chick, (3) to devise a purified diet for use in support of the chemical test for detection of thiamine-inactivating substances and observe the effects of feeding this diet upon thiamine requirement and chick growth.

A total of nine samples of commercial fish meal and fish scrap were obtained from fish supply houses on the West and East Coasts and in the Middle West. In addition, samples of fresh carp tissues were obtained from Spirit Lake, Iowa. All of these fish products were tested chemically for presence of the thiamine-inactivating factor.

Day-old single comb White Leghorn chicks were used throughout all six experiments. A total of 116 lots and 615 chicks were used.

Results of this investigation revealed that observed thiamine deficiency symptoms were, for the most part, in agreement with those previously reported in the literature. Time of onset of the deficiency symptoms was found to be seven to ten days with the control diets as well as with the basal diet containing added thiamine and unheated carp viscera. The time of onset for the other diets depended upon the level of thiamine present in the diet, but symptoms generally occurred between the tenth and twentieth day. Recovery time for the deficient chicks following oral administrations of thiamine was found to vary with the quantity given and the degree of deficiency; for the most part it was rapid, varying from one to five hours with an average of approximately three hours.

Thiamine requirements were observed to vary with type of basal diet used, and ranged from 50 to 80 micrograms thiamine per 100 grams of diet for basal diet #1 (autoclaved natural feed sources, with auto-

[1] Doctorial thesis number 956, submitted June 2, 1949.

claved crude casein as a single source of supplementary proteins), 30 to 60 micrograms for basal diet #2 (autoclaved natural feed sources with three sources of supplementary protein, namely, autoclaved crude casein, soybean oil meal and corn gluten meal) and 80 micrograms for basal diet #3 (purified diet). It was found that the kind of protein and carbohydrate used in formulating the diet had some influence upon thiamine requirement of the chick. Under the conditions of this study, it was found that the samples of the various fish meals and fish scraps used did not appreciably influence the thiamine requirement of the chick.

An analysis of variance test showed significant differences in growth rate of chicks fed the various diets containing different fish meals. It was found that in Experiment I the mackerel fish meal gave highly significant better growth than tuna. Experiment III revealed that menhaden$_1$ fish meal gave a highly significant better growth than tuna. Highly significant differences in rate of growth were obtained in the various lots in Experiment IV; however, no significant differences were found with the 10 and/or 20 per cent menhaden$_1$ and tuna fish meals.

The modified, purified diet was found to give good results as a test diet for use in support of the chemical test in detection of thiamine-inactivating substances. It is believed this diet will be of use in carrying further the thiamine-destruction studies.

THE CHASTEK PARALYSIS OR THIAMINE DESTROYING ENZYME OF FISH TISSUES[1]

HILDA SARVER

From the Department of Chemistry, Iowa State College

The thiamine-destroying enzyme present in certain fish tissues has been studied with regard to its properties and the mechanism of its action on vitamin B_1. The time course of thiaminase action was followed by determining the amount of thiamine destruction at intervals from zero to six hours. However, the instability of the enzyme under the conditions of incubation made it impossible to determine accurately its activity over a long period of time. Within a two-hour incubation period during which time the enzyme retains most of its activity, the reaction went to completion with low substrate concentrations; while with higher concentrations of thiamine there was no indication that the reaction approached equilibrium.

Attempts to approach equilibrium from the opposite direction were made by incubating the thiamine thiazole moiety, 4-methyl-5-β-hydroxyethylthiazole, in the presence of the enzyme with 5-bromomethyl-, 5-methylenesulfonic acid-, and 5-hydroxymethyl-2-methyl-6-aminopyrimidine. However, there was no evidence for the synthesis of thiamine from these components, when they were added in amounts ranging from 1 to 50 micromoles to suspensions of carp tissue, to extracts of acetone-desiccated carp tissue, or to whole-cell preparations of gold fish viscera.

It was found that 4-methyl-5-β-hydroxyethylthiazole, which has been identified as a product of the reaction, in concentrations from 0.1 to 10 x 10^{-2} M. inhibited thiamine destruction by the enzyme from 5.9 to 100 per cent. At present it is impossible to identify this effect with competitive inhibition or with a mass action effect, which by causing a more rapid approach to equilibrium would give the appearance of inhibition.

3-γ-aminopropyl-, 3-β-aminoethyl-, and o-aminobenzyl-4-methylthiazolium halides, structural analogues of thiamine, inhibited thiaminase action, when they were present in concentrations of approximately 10^{-4} M. The inhibition produced by 3-γ-aminopropyl-4-methylthiazolium bromide was increased by the addition of a boiled extract, containing the thermostable, dialyzable component of the enzyme. The effect of 3-δ-amino-butyl-4-methylthiazolium bromide on thiamine destruction by the enzyme was insignificant. On the other hand the addition of o-aminobenzyl- and benzylpyridinium chloride to give concentrations in the range of 10^{-4} M. caused an increased thiamine destruction. The former compound was a particularly effective activator.

[1] Doctoral thesis number 932, submitted August 7, 1948.

With most of the enzyme preparations employed, an apparent substrate inhibition was observed. The amount of destruction decreased with increasing concentrations of thiamine instead of increasing in the expected manner. The addition of a boiled extract partially overcame this inhibition.

Studies directed towards characterizing the thermostable, dialyzable component of thiaminase indicated that no activator was extractable from alkaline or acid boiled extracts with either ether or *n*-butanol. However, the activating factor was precipitated from boiled extracts by approximately 75 per cent alcohol.

Although manganese in its divalent form proved to be an activator for thiaminase, it did not appear to be the specific activator present in boiled extracts. A comparison of the activity of enzyme extracts, which had been dialyzed against manganese-containing solutions, with that of an extract, which had been dialyzed under identical conditions except that no manganese was present in the dialyzate, showed that the activity of both was decreased by dialysis. Since the difference in activity between the two was not great, it appeared that some factor other than manganese was removed by dialysis. The activity of boiled extracts was reduced by treatment with Amberlite IR-100-H and with Decalso, indicating the cationic nature of an activating factor. However, since activity was never completely lost, it appeared that an anionic factor might also be a component of the enzyme system.

Inhibition of thiaminase action by phenylmercuric chloride indicated that this enzyme was sulfhydryl-dependent. Since the activating ability of boiled extracts was not destroyed by the addition of four times the amount of iodine, which was required to titrate an equivalent amount of the extract, it appeared that the sulfhydryl groups, essential for thiaminase action, were located in the apoenzyme. The slight activation of the enzyme produced by cysteine and glutathione could be explained on the basis of the ability of these compounds to maintain the protein sulfhydryl groups in a reduced form.

Reaction mixtures, containing the products of the enzymatic destruction of thiamine, were analyzed spectrophotometrically. The results indicated that the pyrimidine derivative was soluble in *n*-butanol and was adsorbed by Decalso. Unless 4-methyl-5-β-hydroxyethylthiazole, the second product of the reaction, were removed prior to spectrophotometric analysis, the ultraviolet absorption curve, characteristic of 6-aminopyrimidines, was not exhibited. The results of these studies indicated that spectrophotometric methods could be applied in work directed towards the isolation and identification of the pyrimidine derivative.

Attention was given to the anti-thiamine factor of bracken fern, but because of interference produced by fern extracts in the analytical methods for thiamine determination, progress was slow. The factor was more thermostable than most proteins. It appeared to contain both dialyzable and non-dialyzable components. Thiamine inactivation by fern extracts increased with increasing time of incubation, but it was inhibited by mercuric chloride and by 3-γ-aminopropyl- and *o*-amino-

benzyl-4-methylthiazolium halides. Although no definite conclusions can be made regarding the nature of this factor, the possibility still exists that it is a protein and perhaps even an enzyme.

Since studies of the thiamine-destroying factors of fish tissue and of fern required numerous determinations of thiamine, an effort was made to simplify the Melnick-Field procedure, which was generally adopted. A method was developed, similar to the Melnick-Field in that it depended upon the reaction of thiamine in alkaline solution with a diazotized aromatic amine, but less time consuming in that the substitution of *p*-aminobenzoic acid for *p*-aminoacetophenone allowed colorimetric readings to be made directly on the akaline reaction mixtures. The colored complex formed by the reaction of thiamine with diazotized *p*-aminoacetophenone is insoluble, and it is necessary to extract the complex with an organic solvent before colorimetric readings can be made.

STUDIES ON CORN PHENOLOGY AND MATURITY IN IOWA[1]

ROBERT H. SHAW

From the Department of Agronomy, Iowa State College

Corn phenology and maturity studies were conducted on experimental plots located at the Agronomy Farm, Ames, Iowa, in 1947 and 1948, on land of rather uniform soil characteristics. The soil ranged from Webster silty clay loam, with drainage profile intermediate between Webster and Clarion, to Webster silty clay loam with a Glencoe-like boring. The plots were hand planted with a spacing of 40″ by 40″ using three varieties of corn, which in relation to central Iowa were classified as very early, average or medium, and very late. On these plants the following phenological observations were taken on an individual plant basis: date planted, date emerged, date tasseled, date first pollen shed, and date silked. Samples of ears were harvested at various intervals in August, September, October, and November on which the dry weight of the grain and cob, moisture percentage of the grain and cob, and stage of development were determined on all ears harvested. The stages of development used were early milk, late milk, soft dough, hard dough, early dent, middle dent, and late dent. Starch and water soluble content were obtained on a portion of those ears harvested in 1947, and dry weight of 200 kernels was obtained on all ears harvested in 1948. Soil moisture readings were taken at six locations in the field each year at several depths by means of Bouyoucos blocks.

The interval from planted to emerged averaged 12, 11, and 12 days for the early, medium, and late varieties respectively in 1947, and 8, 8, and 9 days in 1948. This interval is important, not so much in its effect on maturity, but in its effect on stand which has an important effect on the final yield.

The interval from emerged to tasseled averaged 65, 72, and 76 days for the three varieties in 1947, and 51, 60, and 63 days in 1948. This interval was the most variable between varieties and between years and has the most effect on changing the time of maturity. However, the difference between varieties was almost the same for the two years. Warm temperatures combined with a plentiful supply of available soil moisture gave more rapid growth and the shortened interval in 1948.

The interval from tasseled to silked averaged 6, 6, and 8 days for the three varieties in 1947 and 6, 4, and 6 days in 1948.

The time rate of tasseling for the three varieties within a year was almost identical and did not vary appreciably between years. The time

[1] Doctoral thesis number 949, submitted June 1, 1949.

rate of silking within a year was relatively constant for the three varieties, but varied appreciably between years.

Maturity was defined as the time the grain reaches maximum dry weight. Several methods were used to determine the time of maturity as defined by that definition: dry weight of the grain, dry weight ratio $R = \frac{\text{dry weight of grain}}{\text{dry weight of grain} + \text{cob}}$ and the dry weight of 200 kernels. The results for the different methods used are presented in Table 1. The curves for the dry weight ratio were fitted by eye. For the dry weight of

TABLE 1

SUMMARY OF DAYS FROM SILKING TO MATURITY AS DETERMINED BY THE DIFFERENT METHODS

Method	Year	Variety		
		Early	Medium	Late
Ratio	1947	50	50	49
Ratio	1948	48	50	54
Dry weight of grain	1948	50	50	54
Dry weight of 200 kernels	1948	51	50	54
Average	1948	50	50	54
Average, 1947 and 1948		50	50	51.5

grain per ear and the dry weight of 200 kernels it was found that the equation

$$y = \frac{L}{1 + e^{\alpha - \beta t}}$$

gave a good fit. In this equation y is the dry weight. L is the maximum value the curve approaches, t is the time in days after silking, and α and β are constants. The period from silking to maturity is very constant, so could be used to forecast the time of maturity, as previously defined, at silking time.

At maturity the moisture of the grain averaged 28.0, 34.5, and 40.0 per cent in 1947 for the three varieties, and 30.5, 36.0, and 40.0 per cent in 1948.

No clear-cut relationship could be found between the stage of development and maturity. The dry weight increased with the stage of development until the middle dent stage in all cases in 1947, with a further increase in some cases through the full dent stage. In 1948 the dry weight of 200 kernels showed that in no case did the average dry weight value reach the maximum in the middle dent stage, while in

the full dent stage the maximum appeared to be reached from 45 to 55 days after silking.

For 15 to 20 days after silking there was a very rapid decrease in the percentage of water solubles. The time of reaching the minimum water soluble content was not closely related to the time of maturity, but was very closely related to the moisture content, and occurred almost identically with the time of reaching 35 per cent moisture. Too few starch determinations were run to determine the relation with maturity, but those run were found to be very highly negatively correlated with the water soluble content.

In corn harvested very early after silking, the moisture content of the grain was higher than that of the cob. In the range of 65 to 75 per cent moisture the relationship changed and the cob moisture became greater. At around 35 per cent moisture the greatest difference was found, amounting to 20 to 25 per cent. At low moisture percentages it is believed this relationship changes to where the grain moisture again becomes greater. But in only one case was the sampling carried to this point, and that was at 16 per cent moisture.

An analysis of variance showed that the variation found in the dry weight of the grain per ear measured in grams was much greater than that found in the moisture percentage of the grain. Computation of the components of variance gave the following results.

Component	Dry Weight of Grain	Moisture Percentage
Replication	37	—0.1
Among hills within replications	492	10
Among ears within hills	1323	22

A variety is believed to be classed as early mainly for two reasons: a shortened interval from emerged to tasseled, and in some cases variety characteristics that allow rapid drying after maturity has been reached.

COLIFORM ORGANISMS AS AN INDEX OF BUTTER QUALITY[1]

RAJ NATH SINGH

From the Department of Dairy Industry, Iowa State College

Coliform bacteria have been used as indices of sanitary quality in pasteurized milk, ice cream, and various other food products. Little systematic work has been done to establish whether or not a similar application can be made in the case of butter. The nature of the process and equipment commonly employed makes it difficult to produce a butter free from contamination; while, on the other hand, washing away of the bacterial food, the distribution of moisture, and the presence of salt make conditions unfavorable for the growth of many microorganisms. The present investigations were undertaken to determine whether counts of coliform and gram-negative bacteria could be used as criteria of butter quality.

The coliform counts were determined on violet red bile agar plates incubated for 18 to 24 hours at 37°C., the gram-negative organisms on plates poured with nutrient agar containing crystal violet dye in proportion of 1:150,000 and incubated for three days at 30°C., the yeast and mold counts on acidified potato dextrose agar incubated for five days at 21°C., and total cultivatable counts on tryptone-glucose-extract-milk agar plates incubated for five days at 21°C. Keeping quality tests were made by incubating the samples of butter at 21°C. for seven days.

Two hundred and ninety-four samples of commercial butter were analyzed for the four groups of organisms. The initial scores ranged from 87 to 93, with 90.2 per cent of all the samples scoring 90 or above. A low coliform count did not insure high-scoring butter, but samples with a high count showed a tendency to score low upon receipt. The same tendency but to a lesser degree was shown in the case of gram-negative count. The yeast and mold count did not bear any relationship to the score of butter on receipt. Both very low and very high total counts tended to be associated with low-scoring butter. The best chances for high score were with butter having a total count between 3,000 and 100,000 per ml. Most of the samples with counts below 3,000 per ml. had cooked, burnt-protein or scorched-fat flavor due to improper pasteurization or excessive heating.

Low coliform counts did not insure good keeping qualities, although high coliform counts, particularly counts over 300 per ml., tended to be associated with decreased keeping quality. The largest percentage of samples that did not lose any points in storage was in the group of

[1] Doctoral thesis number 918, submitted June 30, 1948.

samples with coliform counts of less than 2 per ml., and the lowest in the group with a coliform count of above 300 per ml. Gram-negative counts showed the same tendency, although the trend was less definite. Samples with high yeast and mold counts tended to have poorer keeping keeping quality showed total counts between 10,000 and 30,000 per ml. quality than those with lower counts. Samples of butter with the best Despite a general relationship between the various group counts and the keeping quality of commercial butter, prediction of the keeping quality of an individual sample on the basis of its microbial content was not possible.

The higher the coliform count the higher tended to be the count of gram-negative bacteria, although many samples with high gram-negative counts had low coliform counts. The yeast and mold count usually was higher than the coliform count, although there were a few samples that showed the reverse to be true. The higher the coliform count the higher the total count tended to be, although many samples with high total counts had low coliform counts. Gram-negative count and yeast and mold count showed no relationship.

Samples from fifteen line run series were analyzed for all the four types of organisms. Pasteurization efficiency apparently was high in most cases, but there were evidences of varying degrees of post-pasteurization contamination from vats, pumps, pipe lines, and churns. Buttermilk carried away a large portion of the microorganisms and showed a very high count of all types. Washed granules had comparatively lower counts, the amount of decrease varying from churning to churning. During the process of working, yeast and mold counts frequently increased due to the pickup of large numbers of organisms from the churn wall and probable breaking of clumps, while bacterial counts usually decreased. Coliform and gram-negative counts decreased so greatly during working and salting that even butter churned from grossly contaminated cream frequently had very low counts.

Five semi-commercial churnings were made with highly pasteurized cream inoculated with pure cultures of three strains of *Escherichia coli* and two strains of *Aerobacter aerogenes*. The changes in the population of these organisms at 38° and 48°F. during storage and the effect of salt and working were studied. Salt exerted a very marked germicidal effect on all five cultures of coliform organisms, but the effect of salt was more marked on two strains of *E. coli* than on the third strain of this group and the two strains of *A. aerogenes*.

Low temperature was more effective against *E. coli* than against *A. aerogenes*. During storage the counts of the two strains of the *E. coli* decreased both at 38° and 48°F. and in either the presence or the absence of salt. The third strain of *E. coli* and one of *A. aerogenes* decreased in count when held at 38°F., while at 48°F. there was a decrease both in the beginning and at the end with a short growth period in between. The second strain of *A. aerogenes* showed this decrease followed by an increase at both 38° and 48°F.

Poorly worked salted samples showed higher counts than well worked ones; with unsalted samples the trend was opposite.

The coliform count cannot be used as an index of initial score of butter or of keeping quality of an individual sample. There is, however, a general tendency for samples with high counts to score low and show a poorer keeping quality. Similar statements apply to counts of gram-negative bacteria.

Both counts on line-run samples and controlled laboratory tests show that salt may destroy a large percentage of the coliform bacteria originally present in a sample of butter. Temperature and time of holding and degree of working also influence growth and survival of coliform bacteria in butter.

The field of satisfactory applicability of coliform and gram-negative counts in butter control seems to be confined to determining sources of post-pasteurization contamination, using the test on line-run samples.

ECONOMICS OF EX PARTE 162[1]

WILLIAM HAYTON THOMPSON

From the Department of Economics and Sociology, Iowa State College

The regulation of railroad freight rates and charges on one hand should be directed toward elimination of industry-wide monopoly profits, while on the other hand should seek to determine whether or not earnings are sufficient to maintain an adequate transportation system. Periodically, because of changing national economic conditions, it becomes necessary for the Interstate Commerce Commission to re-examine railroad rates with a view to raising or lowering the general rate level so as to increase railroad earnings.

Following the highly profitable period of wartime operations, the nation's railways by the end of 1945 were faced with declining traffic and revenues and increasing operating expenses. As a result, their net income in early 1946 was small or nonexistent. To offset rising costs, the rail carriers on April 15, 1946, requested the Commission for permission to increase basic rates and charges by 25 per cent with exceptions, on short notice. The subsequent proceedings were known as the Ex Parte 162 general rate level or revenue case.

Before acting upon the 1946 petition, the Commission reopened Ex Parte 148, a previous revenue case suspended in 1943. Through its disposition, no financial emergency was found to indicate that substantial freight rate advances should be granted on short notice. Temporary increases averaging 4.6 per cent effective July 1, 1946, were authorized until the Ex Parte 162 proposals could be further examined. Interim increases, however, proved inadequate to meet rising expenses during the latter half of 1946.

After nearly six months of hearings and deliberations, the Ex Parte 162 petition was decided in December, 1946. It provided approximately one billion dollars in new revenues, the largest sum granted in any rate level case since 1920. However, the advances fell short of meeting anticipated future expenditures. The full amount proposed by the railways was adjudged unreasonable, a fact difficult to explain in view of the continued national inflation. While the increases were intended to raise the aggregate rate of return on property investment, it was difficult to determine whether or not they did so since the Commission and carriers could not agree on the valuation amount to be used as a rate base. When measured against the anticipated corporate and agricultural income for 1947, it appeared that the full amount of the proposed increases could have been borne by the economy without hardship.

[1] Doctoral thesis number 928, submitted August 13, 1948.

On a regional basis, the inflationary lag which occurred in the 1946 proceedings fell with heavy force on the earnings of carriers operating in the Eastern District. To offset a low rate of return, the decision authorized higher freight rates to these roads than to carriers operating in other territories. At the same time, the rate adjustments within and between regions tended to ease the interterritorial rate discrimination prevailing prior to the decision. Southern and western shippers found their competitive disadvantages into eastern markets somewhat lowered by the new freight rates.

Regional economic changes occurring during and after the war had a tendency to broaden territorial markets, and in turn regional freight traffic showed shifting trends. The most significant railroad development during this period was the advance of the western carriers at the expense of eastern roads. Westward shifts in population and industrialization and changes in regional income more than doubled the freight traffic carried by western roads, while that of eastern railways increased only about two-thirds over that of 1939.

Analysis of railway finances for the first six months of 1947 showed the income of eastern carriers to be the lowest of all regions although the rate adjustments were designed to equalize the rate of return in all territories. Relative to other regions, the eastern roads appeared to be in serious financial condition at that time. Their future earnings would undoubtedly depend upon the extent of the movement of industrialization from East to West.

Adjustments made in the rate level of high-grade traffic under the Ex Parte 162 and Class Rate Investigation of 1945 should in the short run make possible higher future volumes of intraterritorial movements than had prevailed during prewar years. This tendency, however, would depend upon the ease and rapidity of industrial reconversion within each region. In the long run, territorial rate adjustments should increase traffic between regions and thus promote a more efficient use of the economic resources of the nation. But a general conclusion as to the effects of both decisions on future traffic is difficult because of lack of data pertaining to regional and national commodity rate structures and levels. Further progress in this direction can be made only when it is possible to investigate scientifically the nationwide commodity rate levels.

Production and distribution of separate products were affected differently by the rate advances. Straight uniform percentage increases on agricultural traffic tended to increase the disadvantages of long-haul shippers over those located shorter distances from common markets. At the same time, by allowing percentage increases with specific maxima on certain commodities in this classification, an attempt was made to maintain existing market relationships. Increases on lumber were intended to continue competitive markets prevailing before the decision. As applied to coal shipments, the advances were designed to equalize markets but appeared to have the same effect as though granted on a percentage basis. Long-distance shippers or receivers of coal would be at a disadvantage compared with those located closer to mines

or markets. Significant changes in production and distribution of steel could result from the percentage increases on this commodity. Markets tended to become narrower as distant basing points were compelled to absorb increased freight charges when competing with mills located closer to fabrication areas.

General conditions of high postwar demand and short supplies of consumer goods, and the short run monopoly position held by railroads in the transportation industry make it seem probable that the full amount of the rate increases were passed on to the ultimate consumer.

Of the agencies comprising the national transportation system, water and motor common carriers seemed to benefit most by the Ex Parte 162 advances. Charges of the former were raised simultaneously with those of the railroads, and for this reason it is unlikely that substantial traffic was diverted. Motor trucks waited longer for rate increases and some diversion may have taken place, especially in short-haul movements. The most serious competitive problem for the railroads appeared to be in the area of private motor and water transportation. While impossible to determine accurately, losses of traffic from rail to private carriers may have been substantial as shippers found it more profitable to increase their use of private facilities.

The Ex Parte 162 case may be considered as part of the first phase of the postwar rate level adjustments. Percentage increases were made as the most expeditious means of raising railroad revenues to offset increased costs. Railroads prefer this method since they can raise individual rates as much or as little as suits their purpose. Consequently, in spite of efforts to "hold down" the competitive differences, discriminations tend to become more pronounced in the wake of general percentage increases. The second phase will undoubtedly consist of selective adjustments in individual or groups of rates. This procedure may be expected to extend over many years.

DYNAMICS OF THE *STREPTOCOCCUS LACTIS* BACTERIOPHAGE RELATIONSHIPS [1]

GEORGE ERNEST TURNER

From the Department of Dairy Industry
Iowa State College

By use of a two-layer agar plate technic a method for enumerating the plaques produced by some bacteriophages active against *Streptococcus lactis* was developed. The technic consisted of allowing a basal layer of approximately 12 ml. of sterile tomato juice-peptonized milk medium of 1 per cent agar strength to solidify in a petri plate; on this basal layer was placed an overlay composed of 1 ml. of a water suspension containing approximately 28 million susceptible *S. lactis* cells per ml., 1 ml. of a suitable dilution of an homologous bacteriophage strain suspended in milk, and 1 ml. of the tomato juice-peptonized milk medium containing 1.5 per cent agar. After thorough mixing, the plates were placed on a level surface to allow the top layer to solidify. Enumeration of the developed plaques was possible after 10 to 12 hours incubation at 30°C. By this procedure reproducible counts of bacteriophage particles in various preparations could be obtained.

Maximum plaque numbers were obtained with a 3 ml. volume overlay containing a final agar concentration of 0.5 per cent. Increasing the agar volume and/or the agar concentration of the overlay decreased the number of demonstrable plaques.

Maximum plaque numbers were evident using a concentration of *S. lactis* cells of about 28 million per ml. in the cell suspension added to the agar overlay. Concentrations of cells appreciably lower or greater than this optimum resulted in lower plaque numbers.

If three of the five strains of bacteriophage studied were suspended in water for addition to the plates, the plaque count decreased to less than one-half that obtained when the particles were dispensed in milk. Addition of milk to the agar overlay containing the water-dispensed bacteriophage particles restored the plaque count to its former value. Dispensing the other two strains in either water or milk had no effect on the plaque numbers.

Sterilization of milk used as a bacteriophage-dispensing medium at 15 pounds steam pressure for periods of time as long as 45 minutes caused a significant drop in plaque counts. Maximum counts were obtained with milk sterilized at 15 pounds pressure for 20 minutes.

Considerable decreases in plaque counts were obtained when the reaction of the plating medium was not within the range of *p*H 5.8 to 6.0.

[1] Doctoral thesis number 940, submitted December 13, 1948.

Results by the plaque plate method for enumeration of bacteriophage particles were slightly higher than those by the limiting dilution method.

The five bacteriophage strains studied proliferated by stepwise increase, the probable burst time being approximately sixty-five minutes and the average burst size about ninety countable particles.

The proliferation curve of each of the five bacteriophage strains studied possessed lag, logarithmic, and resting phases. The slope of the logarithmic part of each curve was directly dependent upon that of the susceptible *S. lactis* strain of organism, whose growth in turn was conditioned by the temperature of incubation. The optimum rate of multiplication for both the bacteriophage and the susceptible cells occurred at 32°C. Certain *S. lactis* bacteriophage strains studied at incubation temperatures higher than 32°C. failed to proliferate, while reasonably good growth of the susceptible cells was obtained when these higher temperatures were employed. One bacteriophage strain failed to proliferate at an incubation temperature of 35°C., a second at 37°C., and a third strain at 38.5°C., while the homologous organism multiplied in each case.

At the incubation temperature of 32°C. the lag period of the *S. lactis* bacteriophage strains studied was generally about two hours, but became progressively longer as the temperature was varied from the optimum. Even at this temperature the length of the bacteriophage lag could be varied by changing the numbers of susceptible cells initially added to a given number of countable bacteriophage particles. When the ratio of susceptible cells to bacteriophage was increased progressively, the lag period became correspondingly shorter, although no significant difference was noticeable in the slope of the logarithmic part of the bacteriophage proliferation curve regardless of the initial concentration of susceptible cells.

Progressive increases in the ratio of bacteriophage particles to susceptible cells stopped bacterial increase when more than one bacteriophage particle per cell was present, while the bacteriophage continued to increase rapidly until the bacterial cells were lysed.

When bacteriophage proliferation took place, the rate of increase always exceeded that of the susceptible cells at the same temperature, and mass lysis of these cells in the culture eventually took place. The time required to reach mass lysis of the susceptible cells was shortest at the optimum temperature of 32°C. and was progressively longer as the temperature varied from that of the optimum.

Following mass lysis of susceptible cells by the homologous bacteriophage strain, secondary growth of cells took place immediately in the case of four of the five strains studied. The fifth *S. lactis* strain failed to show evidence of secondary growth even after incubation for two weeks at 32°C.

Acid production stopped in the lysed cultures of all five bacteriophage strains at the time of lysis, while the corresponding control cultures continued to produce satisfactory amounts of acid.

The extremely rapid rate at which bacteriophage is capable of pro-

liferating and the absolute stoppage of acid production at the time the cells are lysed definitely point to the necessity of preventing a build-up of bacteriophage in the cheese milk. The comparative rates of bacteriophage development at the different temperatures show why a culture incubated at 21°C. after a light bacteriophage infection may show little or no effect of bacteriophage, while that culture placed at 30°-32°C. in the cheese vat will undergo lysis and cessation of acid production in a rather short time when other circumstances are favorable.

SOME PHYSICAL AND CHEMICAL PROPERTIES OF PLANOSOL AND WIESENBODEN SOIL SERIES AS RELATED TO LOESS THICKNESS AND DISTRIBUTION[1]

RUDOLPH ULRICH

From the Department of Agronomy
Iowa State College

A study was made of the nearly level, poorly drained Wiesenboden and Planosol soils developed from Peorian, or Wisconsin, loess in southwestern Iowa. In the field, the study included loess thickness and distribution pattern, morphological observation and description, and the collection of representative soil core and bulk samples. In the laboratory, physical and chemical tests and measurements were conducted.

In accordance with the general direction of prevailing winds during the time of loess deposition, two northwest-southeast traverses were established. These were called Traverses No. 3 and No. 4 to prevent confusion with Traverses No. 1 and No. 2 established by a previous investigator in the same area for the gently sloping Prairie soils.

Six soil profiles along Traverse No. 3 and additional data by the author and other investigators for Traverse No. 4 were investigated. The more complete findings for the six profiles along Traverse No. 3 comprise the principal subject matter of the study. From northwest to southeast, the six profiles include: (1) Minden, P-217, silt loam; (2) Winterset, P-218, silty clay loam; (3) Winterset (?), P-222, silty clay loam; (4) Haig, P-221, silty clay loam; (5) Haig, P-220, silt loam; and (6) Edina, P-16, silt loam. The respective distances for these profiles from point of initial loess deposition are: (1) 43 miles, (2) 109 miles, (3) 121 miles, (4) 129 miles, (5) 143 miles, and (6) 173 miles.

Loess thickness measurements, obtained at or near the profile sites, showed that the loess thins with distance in a southeasterly direction as one proceeds away from the point of initial deposition—the bluffs immediately east of the Missouri River. As was also found in several previous studies of Peorian loess deposits in southwestern Iowa and central Illinois, the rate of decreasing loess thickness with distance from source of loess supply appears to be regular and exponential. The loess thicknesses at five of the profile sites along Traverse No. 3 are: (1) Minden, P-217, 405 inches;[2] (2) Winterset, P-218, 130 inches; (3) Haig, P-221, 112 inches; (4) Haig, P-220, 105 inches; and (5) Edina, P-16, 90 inches.

Morphological, chemical, and physical soil profile properties are functionally related to the loess thickness-distance pattern.

[1] Doctorial thesis number 972, submitted June 6, 1949.
[2] Interpolated value from curve of thickness vs. distance.

In the field, these profiles reveal great morphological differences. The Minden series has a uniform textural, structural, and color Prairie soil profile with indistinct horizon differentiation. The conspicuously developed Edina series of the Planosol great soil group has a pronounced ashy gray A_2 horizon with a dense, slowly permeable clay pan subsoil. The intervening Wiesenboden soil profiles of the Winterset and Haig series indicate intermediate stages of profile development.

Mechanical analyses and clay fractionation studies indicate that the conspicuous textural profiles developed along Traverse No. 3 are the result of formation, movement, and accumulation of large quantities of fine (less than .06 micron) clay with increasing profile development. This fine clay appears to form initially in the subsurface horizons and to move to and accumulate at considerable depths in the profile. As profile development continues, the amount of fine clay in the maximum clay accumulation horizon increases, and the maximum clay horizon occurs closer to the surface. The formation, movement, and accumulation of fine clay occur before the profile becomes appreciably acid and while the degree of base saturation is still fairly high. The Haig, P-220, profile appears to be undergoing the maximum rate of organic and inorganic eluviation and illuviation. In the Haig, P-220, profile the incipient ashy gray, or A_2, horizon has a *p*H of 5.3 and a base saturation of 76 per cent.

Other important physical changes accompany the formation of conspicuous textural profiles. While less discernible, these physical properties have important influences on soil moisture, soil aeration, and plant root environmental relationships. These additional physical changes accompanying the formation, movement, and accumulation of fine clay include: (1) increasing volume weight, (2) decreasing aeration and total porosity, and (3) decreasing permeability. These changes are most prominent in the horizons of maximum clay accumulation, but they also occur to a lesser extent in the A_2 horizon, the horizon of maximum eluviation.

Chemical changes accompanying increasing profile development include increasing *p*H and cationic eluviation, possibly in the order $Na > K > Ca > Mg > H$.

Changes in the organic constituents in the surface horizons, or in the zone of maximum organic matter accumulation accompanying increasing profile formation includes decreasing total nitrogen, organic carbon, organic matter, and carbon-nitrogen ratio.

With climate, vegetation, and topography nearly constant, parent material and time of weathering are the two most important variable soil forming factors accounting for the pronounced profile variations and development observed along Traverse No. 3. Of the two, parent material and time of weathering, it is believed time of weathering is the more important soil forming factor. In accordance with the sequence concepts of Jenny, it is believed these profiles comprise a chronosequence.

The physical, chemical, and organic changes occurring in the profiles investigated indicate soil formation is the result of closely related, dynamic, and for the most part, irreversible processes rather than static or equilibrium processes. The soil profile is not a closed system, and numerous constituents are lost during profile formation. In such a system, irreversible rather than equilibrium processes are to be expected. Although there are indications that many processes, such as fine clay formation and movement, are no longer as active as formerly in the Edina profile, these processes are still continuing at a much reduced rate asymptotically approaching but probably never reaching static or equilibrium conditions. Assuming equilibrium were attainable, it would be only partial, not total in effect; and it would involve only a few end products, not the complete soil formation processes.

ANAEROBIC DISSIMILATION OF PYRUVATE BY BACTERIA[1]

DEAN DAY WATT

From the Department of Bacteriology
Iowa State College

Pyruvate may be referred to as the hub of the metabolic wheel because of the unique position which the compound occupies. Additional information concerning its metabolism should prove of value to our knowledge of intermediary metabolism. The purpose of this investigation is to study the anaerobic dissimilation of pyruvate by bacteria, particularly *Micrococcus pyogenes* var. *aureus* and *Aerobacter aerogenes*.

Anaerobically *M. pyogenes* var. *aureus* dissimilates pyruvate by at least two different mechanisms depending upon the conditions of growth. Cells grown under conditions favorable for the development of acid (i.e., growth in a medium containing glucose) dissimilated pyruvate to form a mixture of products: acetylmethylcarbinol, 2,3-butyleneglycol, acetate, lactate, and carbon dioxide. These cells carried out a mixed dissimilation. If, however, the cells were grown in a glucose-free medium, dismutation was predominant. Lactate, acetate, and carbon dioxide with a trace of acetylmethylcarbinol were produced as described by Krebs (1).

The enzyme system which formed acetylmethylcarbinol from pyruvate requires diphosphothiamine. Neither diphosphothiamine nor phosphate was necessary for dismutation. With the dismutation reaction the formation of an energy-rich phosphate linkage could not be demonstrated either by direct analysis or indirectly by measuring phosphate transfer to a suitable acceptor such as adenosine-5-phosphate.

The reversibility of the dismutation reaction was studied by using the stable isotope of carbon, C^{13}. The labeled compounds bicarbonate, carboxyl-labeled acetate, and carboxyl-labeled lactate were added to a cell suspension which was dismutating pyruvate. If the reaction can be reversed, one would expect to find the isotope in the positions indicated by the following equations:

(1) $CH_3CHOHC^{13}OOH \rightarrow CH_3COC^{13}OOH + 2H$
(2) $CH_3COOH + C^{13}O_2 \rightarrow CH_3COC^{13}OOH + 1/2\ O_2$
(3) $CH_3C^{13}OOH + CO_2 \rightarrow CH_3C^{13}OCOOH + 1/2\ O_2$

In the presence of carboxyl-labeled lactate, pyruvate was isolated which contained an excess of C^{13} in the carboxyl group. With respect to lactate, the dismutation reaction is reversible. Similar results were obtained when isotopic bicarbonate was added to the metabolizing mixture. An excess of C^{13} was found in the carboxyl of pyruvate, thereby

[1] Doctoral thesis number 952, submitted May 31, 1949.

indicating reversibility. Adenosine triphosphate enhanced this reversibility. The reversibility in the presence of labeled carbon dioxide is in reality a fixation of carbon dioxide. Under conditions of synthesis, such a fixation may assume considerable importance in the assimilation of cell constituents.

The reversibility with respect to carbon dioxide indicated that acetate would also participate in the reverse reaction. If carboxyl-labeled acetate is added to the metabolizing mixture, an excess of C^{13} should be found in the carbonyl carbon of pyruvic acid. No excess C^{13} was found in this position. Adenosine triphosphate did not enhance the reversibility. Some two-carbon fragment other than acetate is participating in the reverse reaction in order for carbon dioxide to be fixed. Under the conditions of these experiments, acetate was not converted to the unknown two-carbon compound.

Anaerobically, pyruvate is dissimilated by a cell-free extract of *Aerobacter aerogenes* to form acetylmethylcarbinol and carbon dioxide (3). Results of the present investigation prove that this reaction is inhibited by phenylpyruvate. The inhibition is competitive and specific for a class of anaerobic dissimilative reactions of pyruvate which require diphosphothiamine as a coenzyme. However, diphosphothiamine does not reverse the inhibition. The inhibition may be reversed by increasing the concentration of pyruvate.

The kinetics of the inhibition are studied by a method outlined by Lineweaver and Burk (2). The Michaelis constant K_s for the enzyme-substrate complex was found to be in the order of 5.0×10^{-2} moles per liter. The constant for the dissociation of the enzyme-inhibitor complex, K_i, is in the order of 6.0×10^{-5} moles per liter. Within limits the value of K_s was essentially constant regardless of the concentration of the enzyme. The maximum velocity was essentially constant in the presence or absence of inhibitor indicating that the inhibition was competitive.

LITERATURE CITED

1. Krebs, H. A.
1937. Dismutation of pyruvic acid in gonococcus and staphylococcus. Biochem. Jour. 31, 661–71.

2. Lineweaver, Hans, and Dean Burk
1934. The determination of enzyme dissociation constants. Jour. Amer. Chem. Soc. 56, 658–66.

3. Silverman, M. and C. H. Werkman
1941. The formation of acetylmethylcarbinol from pyruvic acid by a bacterial enzyme preparation. Jour. Biol. Chem. 138, 35–48.

CHARACTER INHERITANCE, FERTILITY RELATIONSHIPS, AND MEIOSIS IN *MELILOTUS*[1]

GILBERT T. WEBSTER

From the Department of Agronomy
Iowa State College

The genus *Melilotus* includes approximately twenty species of which only two are extensively used in commercial varieties of sweetclover. In all species which have been examined, eight chromosome pairs have been found, yet sterility barriers seem to prevent the occurrence of natural cross fertilization between species. Attempts at artificial hybridization have given variable results ranging from complete lack of compatibility to hybrids which are semi-fertile. In the present study, character inheritance, pollen condition, self-fertility, and meiosis were investigated in interspecific hybrids among three species. These hybrids were from the crosses *M. suaveolens* (annual) x *M. alba*, and the reciprocal cross, *M. alba* x *M. suaveolens* (biennial), *M. alba* x *M. polonica*, *M. polonica* x *M. suaveolens* (annual) and *M. polonica* x *M. suaveolens* (biennial). Hybrids between *M. suaveolens* (annual) x *M. wolgica*, *M. italica* x *M. messanensis*, and *M. alba* x *M. taurica* are also reported.

Pollen analysis of F_1 hybrids showed an average of approximately 75 per cent aborted pollen and 20 per cent self-fertility. Parent plants of these hybrids exhibited from 95 to 100 per cent normal pollen and an average of nearly 45 per cent self-fertility under greenhouse conditions. The mean percentages of normal pollen and self-fertility increased in the F_2 and F_3 generations, and several plants showing normal pollen and high self-fertility were recovered. Marked differences in percentage of stainable pollen were noted in the F_1 means and F_2 distributions of the cross *M. suaveolens* (annual) x *M. alba* and its reciprocal. The F_1 means differed by more than 30 per cent, and the F_2 distribution curves showed nearly opposite trends. The percentage of stainable pollen was shown to be influenced in some degree by environmental factors of an undetermined nature. Isogenic lines, obtained by means of vegetative cuttings from the same plant, occasionally gave significantly different pollen condition readings. Percentage of stainable pollen and self-fertility in the F_1 plants were found to be postively correlated. Ovule abortion was apparent, although of a lower frequency than pollen obortion.

Meiosis in F_1 species hybrids appeared to be as normal as that of the parent plants. Eight bivalents were present at diakinesis and

[1]Doctoral thesis number 968, submitted June 3, 1949.

metaphase I. Anaphase I and II resulted in eight and eight distributions in nearly all cells where counts could be made accurately. No supernumerary micronuclei were observed. Pollen abortion was concluded to be affected by factors other than meiotic irregularities. An hypothesis of pollen degeneration resulting from certain lethal gamete combinations is suggested.

Annual growth habit appeared to be conditioned by a single major dominant gene in crosses between annual and biennial forms of *M. alba* and *M. suaveolens*. Biennial segregates were obtained in the F_2 progeny of a cross between annual forms of *M. alba* and *M. suaveolens* suggesting different genes in each of the two species. A third gene was indicated from the results of crosses between *M. polonica* and *M. suaveolens* (annual) in which an F_2 ratio of nine annual to seven biennial types was observed.

Flower color in crosses between yellow- and white-flowered species appeared to result from the action of at least three major genes. First generation hybrids produced cream-colored flowers, and in the F_2, varying shades of cream color predominated. Only 1.9 per cent yellow and 16.0 per cent white types were recovered.

Seed weight seemed to be inherited on a polygenic basis with incomplete dominance. The large seed size of the *M. polonica* parent was not recovered among the F_2 progeny. Seed size was found to be influenced according to the species used as the pollen parent in reciprocal crosses. In crosses between *M. alba* and *M. suaveolens*, a reduction in seed size was noted when *M. suaveolens* was the male parent, while in the reciprocal cross, no differences were found between selfed and crossed seed.

Partial dominance for a large number of flowers per raceme was noted in the F_1 plants of crosses between *M. alba* and *M. suaveolens* with the sparsely flowered species, *M. polonica*. In the F_2, the mean flower number was depressed toward that of the *M. polonica* parent, and a further reduction appeared in the F_3 generation. Number of flowers per raceme and seed weight were negatively correlated in the F_2 generation of the cross between *M. polonica* and *M. suaveolens* (annual).

THE MOISTURE GRADIENT AND ITS EFFECT IN THE DRYING OF CLAYWARE[1]

WILLIAM JAMES WRIDE

From the Department of Chemical Engineering, Iowa State College

It has been known for some time that cracking of clayware could be caused by improper drying conditions. In general, the losses due to cracking have been assumed to be caused by too high a moisture gradient from drying surface toward the center of the ware. Previously published work has shown how and why these gradients are set up, and methods of calculating the gradients for particular cases for flow of moisture in one direction during drying have also appeared in print.

This work has carried the analysis a step further by determining the manner in which moisture gradients enter into the mechanism of stress build-up, and their importance relative to other factors influencing the magnitude of the stress.

It has been shown in this work why the most critical drying period occurs when the clay at the surface is approaching or has reached its shrinkage limit while the clay on the interior is still shrinking.

Knowledge of the magnitude of the moisture gradient alone is not sufficient information upon which to base a prediction of drying success or failure due to cracking. Equally as important is the knowledge of the actual moisture content at the surface of the drying body for a given moisture gradient. These facts together with the results of shrinkage tests enable one to calculate the unit strain at the surface caused by the differential shrinkage between the surface and the center of the body. It has been pointed out that a relatively high moisture gradient may exist with no ill effects whatever if the center of the cube has already reached its shrinkage limit. Only residual strains would be present in this case.

Another factor of great importance is the modulus of elasticity for the material. Experiments were conducted to determine the relationship between modulus of elasticity, E, and moisture content, M. It was found that E increases quite rapidly with a decrease in M, particularly in the drier range. The function relating E and M was found to be hyperbolic over the most critical moisture range. Because stress is a function of unit strain times modulus of elasticity, the tendency of E to increase with decreasing moisture content explains why a certain moisture gradient in the early part of the drying run would not cause cracking, but the same moisture gradient at or near the shrinkage limit would cause failure of the ware.

[1] Doctoral thesis number 939, submitted December 13, 1948.

An explanation can thus be offered for the fact that in the runs conducted in this work all test specimens that cracked in drying did so when the clay was at or near the shrinkage limit. In the wetter range the moisture gradient, in all probability, has not reached its peak value. Therefore, the unit strain is low. The modulus of elasticity is also low in this range. Thus a low stress is the result.

As the shrinkage limit was approached the moisture gradient was generally still increasing thus causing a maximum strain at this point. The modulus of elasticity increases throughout the run which means that the highest stress condition occurs at this point also.

Below the moisture content at which the surface has reached the shrinkage limit, the unit strain decreases quite rapidly so that the stress is reduced in spite of a further increase in modulus of elasticity.

It has been shown graphically how the various factors that cause drying stresses are related. Data and calculated results from selected tests on both a calcium clay and the same clay to which was added 0.2 per cent sodium silicate support the conclusions which have been presented above.

Forty different drying tests were made of a commercial hotel-china clay body under severe drying conditions in an attempt to make the clay crack. The drying tests were interrupted at the time the first surface cracks appeared, and the moisture gradients from surface to center of the cubical specimens were determined gravimetrically. These were found to be hyperbolic in shape, and in every case the moisture range extended from a value below the shrinkage limit at the surface to a value above the shrinkage limit in the center of the cube.

Flexural tests were made on cylindrical clay bars to determine the modulus of elasticity as a function of water content. Because wet clay is only partially elastic, a modified modulus was calculated which it was believed was most nearly applicable to the clay material under drying conditions.

The percentage linear shrinkage of the wet clay body as a function of water content was obtained from continuous readings on an automatic drying shrinkage machine.

A series of tensile tests at different moisture contents was made for each of the two types of clay. Although no standard method for this determination has yet been adopted for a material such as wet clay, an adaptation of the A.S.T.M. cement mortar tensile test was made, and it is believed that a fair approximation of the true values was obtained. Recommendations were made which should give improved accuracy of these results.

It has been recommended that further work be done to determine the type of relationship between modulus of elasticity and water content and between tensile strength and water content for a number of clays. This is necessary before a rigorous theoretical stress analysis can be made and the results applied in predicting a maximum safe rate of drying.

A change in drying precedure for clayware based on the results of this investigation has been recommended. It is a common practice today to begin an air-drying operation with air at a medium temperature (150°F.) and a high humidity. As drying progresses, the air used is at a higher temperature and a lower humidity. This means that the drying rate is quite low in the initial portion of the run.

It has been suggested by the author that a higher rate of drying be obtained by using air of lower humidity in the initial portion of the run. When the average free-moisture content of the ware is slightly above (4–5 per cent) the shrinkage limit, the humidity of the air should be increased until the ware has passed the critical range of moisture content. It may then be lowered to allow the ware to dry as fast as other practical considerations permit.

This procedure should be feasible, because drying stresses are very low in the early part of the drying operation.

This procedure would have the added advantage of greatly reducing the present difficulty of condensation on the ware when it is first placed in the drier.

MASTERS' THESES

JULY 1, 1948—JUNE 30, 1949

List of the authors and titles of theses submitted to the graduate faculty of Iowa State College in partial fulfillment of the requirements for the degree Master of Science, July 1, 1948, to June 30, 1949.

AERONAUTICAL ENGINEERING

Wu, Theodore Yao-Joe
A study of Kantrowitz's nozzle for the measurement of heat capacity lag of gases.

AGRICULTURAL ENGINEERING

Beach, William Eugene
Factors affecting performance of tile ditching machines.

Benedict, Russell Herman
Methods and costs of terrace construction under Iowa conditions.

Boyd, Landis Lee
The effect of moisture content of wood on withdrawal resistance of roofing nails.

Chiang, Yao
Design of a reaper for use under Chinese conditions.

Cleveland, Roger Myron
Wind and hail damage to asphalt shingles in Iowa.

Downing, Charles Glenn Eldrick
Application of principles of heat exchangers in dairy barn ventilation.

Everett, Aubrey Cortez
Soybean harvesting losses with the combine.

Gattis, James Lloyd
Factors affecting the durability of mole drains.

Griffin, Jack G.
Nozzle placement and spray distribution pattern in the design of chemical weed control equipment.

Hanna, George Bassily
Development of a variable width trench excavator.

Johnson, Erwin Roy
Design and development of a tractor mounted grain windrower.

Palmer, Elwine Duane
Effect of dimensional changes of lumber on strength of glued joints.

Pandya, Amarendra Chandrashankar
Some effects of temperature change on aluminum sheet roofing.

Renoll, Elmo Smith
Tillage, weed control, and corn yields on certain Iowa soils.

AGRONOMY

AGRICULTURAL CLIMATOLOGY

Neill, James Clemens
Weather effects on corn pollination.

Waggoner, Paul Edward
Temperature height relations over bare ground and potato plots on peat and mineral soils.

FARM CROPS

Bartley, Basil George
Influence of variety and environment on factors determining quality in oats.

Keller, Ernst Robert
Effect of photoperiod on red clover and timothy strains grown in association.

Mukerji, Sunil Kumar
Effect of planting methods on agronomic performance and protein content of orchard grass strains.

Taylor, Lincoln Homer
Association of meiotic irregularities with agronomic performance in *Dactylis glomerata* L. clones.

Zapata, Victor Manuel
Forage yield and protein content of low crown and erect types of alfalfa under frequent clipping treatment.

SOILS

Anderson, Marvin
Some physical and chemical properties of six virgin and six cultivated Iowa soils.

Penly, William John
Design of reinforced concrete dome structure to withstand extremely high blast pressures.

Peperzak, Paul
Phosphorus compounds in manures.

Smith, Donald Henry
Influence of legume and grass associations on soil microbial populations and on phosphorus content of plants.

ANIMAL HUSBANDRY

Barker, Hal Burnette
Filled milks for dairy calves. IV. Comparative value of various soybean oils and butter oil in a practical calf ration.

Barnhart, Charles E.
Methods of measuring quantity of sows' milk and effect of rations on selected vitamin content.

Bell, Howard Kirtland
Dehydrated alfalfa products for growing and fattening pigs.
Cheng, Edmund Wei-kuang
The vitamin A requirement for growing and fattening pigs.
McLeroy, George B.
The influence of meteorological phenomena upon the summer milk production of Holstein Friesian cows.
Magee, William Thomas
Inheritance of scrotal hernia in inbred swine.
Magrabi, Mohamed
Variability in "line-test" response of rats caged individually and in groups when fed the same dose of vitamin D.
Murley, Winifred Ray
Filled milks for dairy calves. II. Comparative effect of soybean oil and butter oil on growth and various constituents of the blood.
Sidwell, George Madsen
Size of lambs at weaning as a permanent characteristic of Navajo ewes.
Vernon, Eugene Haworth
Sex ratios among inbred, non-inbred, and line-cross pigs.
Williams, James E.
Corn from high and low productive lands for growing and fattening pigs.
Yang, Shiang Ping
Absorption of vitamin A and carotene by dairy calves. II. Effect of type of dispersion.

APPLIED ART

Petersen, Neva Maurine
Designing and making place mats using various media and processes.

AGRICULTURAL ENGINEERING

Neay, Thomas Woo
A proposed design of a manufacturing plant for structural clay products in Canton, China.
Witters, Arthur George
The United States Air Force Academy.

BACTERIOLOGY

Chang, Yuan Mou
Synthesis of nicotinic acid by bacteria.

BOTANY

Cooper, George Raymond
Some responses of black locust to planting site treatment.

Hatfield, Marion Robert
The nutritional requirements of *Phytophthora infestans* (Mont.) de Bary, in culture.
Kucera, Clair Leonard
Some effects of cultural treatments on secondary plant succession on an eroded Lindley Soil.
Taylor, Gordon Stevens
Resistance of maize from Guatemala and the United States to *Helminthosporium turcicum* Pass.

CHEMICAL ENGINEERING

Blickwedel, Theodore William
Decomposition of monazite.
Chang, Hson Mou
Separation of menthol from peppermint oil by fractional distillation.
Chiang, Lan Sun
Preparation of high test bleaching powder by chlorination of lime slurry.
Feldman, Max L.
Solvent extraction of aqueous solutions of rare earths.
Kremer, Lewis Albert
Economics of the production of ethanol.
Liu, Fu-Kuang
Separation of fines from miscella in soybean oil extraction.
Long, John Reed
The use of ammonium bifluoride in the preparation of fluorides from oxides.
Rada, Charles Henry
Organic acid absorbers for base exchange.
Sen, Deba Prasad
An economics study of destructive distillation of Indian coal.
Snyder, Edward Graydon
Effect of trichloroethylene on catalyst life in hydrogenation of soybean oil.
Stringfellow, Arthur C.
Preparation of improved sulphonic type resinous cation exchangers for water treatment.

CHEMISTRY

Bever, Robert J.
Applications of an improved high-frequency conductimetric titration apparatus.
Johnson, Harlan Bruce
Studies of thorium alloys.
Knapp, Doris Marie
Quantitative aspects of maltase action.

McIntire, Robert Lillis
Reaction of periodate with Schardinger dextrins.
Mathews, John Jr.
Reaction of ferrous iron with nioxime.
Pool, Edwin Lewis
Effect of phytohormones on the growth of certain microorganisms.
White, Philip Louis
The metabolism of l-tyrosine by normal and scorbutic guinea pigs.

CHILD DEVELOPMENT

Fantop, Ola B. Allen
Adequacy of home play environment of a group of nursery school children.
LaVanway, Priscilla Lorraine
Relation of nutritional status to motility, intellectual performance, and personality of a group of Iowa school children.
Seiser, (Mrs.) Marjorie Betts
Parents' use and evaluation of readily available child guidance material.
Stewart, Katherine Glass
Differences between fathers and mothers in knowledge of and attitudes toward child behavior.

CIVIL ENGINEERING

Gardiner, William Pringle
Calculation of soil density from shrinkage properties.
Glab, John Edward
The effect of organic cationic admixture upon two natural soils.
Handforth, Colin Hunter
Combined stresses in the connections of flexible underground conduits.
Henderson, Donald Horton
Practical methods of applying large organic cations as soil waterproofing agents.
Hesse, Richard Joseph
Selection of equipment for field hydrologic studies.
Hulsbos, Cornie Leonard
Maximum unit stresses in eccentrically loaded hinge-fixed columns.
Jensen, Emmanuel Tranberg
Computed secondary stresses in the Niagara railway arch bridge compared with field measurements at two top chord panel points.
Kayerker, Mahipatrao Venkatrao
Planning highway systems in agricultural areas with applications to India.
King, Harry Lane, Jr.
Electro-chemical strengthening of soil adjacent to friction piles.

Norman, Clarence C.
Air loss in placing air-entrained concrete in concrete pavement construction.
Patel, Ochhavlal Hinatlal
Stabilization of gumbotil soil for highway use.
Rahman, Shafiquer
Use of brick and burned shale in stabilized road construction.
Sarmah, Golok Chandra
Adhesion of bituminous binders and wet mineral aggregates
Sarman, Halit Ziya
Stabilized soil roads for Turkey.
Sompura, Gulabray Bhaishanker
Effect of variation of moisture content in soil-cement mixtures.
Sundlof, William Adolph
Effect of wetting time on plasticity indices of eight soils.
Williams, Donald Glazier
Design of reinforced concrete arch structure to withstand extremely high blast pressures.

DAIRY INDUSTRY

Kristoffersen, Thorvald
Lipolysis as a factor in the ripening of cheddar cheese.
Van Devender, Virgil Clinton, Jr.
The ammonia content and formol titration of roll-dried buttermilk powder as indices of the quality of the buttermilk from which the powder is prepared.

ECONOMICS AND SOCIOLOGY

ECONOMICS

Danton, Lawrence Alonzo
Economic factors in the development and operation of self-service laundries in Iowa.
Day, Lee Monroe
The administration of resources in pork production as related to the marginal rates of corn/protein substitution.
Fan, Shou-Ching
Analysis of the demand for meat in the United States, 1910-1947.
Glassburner, John Bruce
The effects of taxation on the use of resources.
Graves, Douglas Foch
Problems and practices in making farm and home improvements on rented lands in Iowa.
Hess, Carroll Vernon
Forces conditioning economic use of resources on southern Iowa farms.

Maliet, Leonard Dale
An analysis of overhead for the Iowa State College Press.
Regier, Donald Wilson
The concept of consumption among the physiocrats and the classical economists.
Scales, Valda Minna
The effects of the United States Wool Tariff at varying rates on the Australian and United States wool industries and trade in wool.
Stewart, Clyde Everett
Investment practices and opportunities of purchasers of farm land in Story County, Iowa.
Walker, Scott Allen
Economic analysis of the multiproduct dairy plant.

SOCIOLOGY

Bohlen, Joe Merl
Factors related to migration intentions of high school seniors Hamilton County, Iowa, 1948.
Boulding, Elise Marie
Factors in family situations which influence the course of adjustment to war separation and reunion.
Schmidt, Robert Julius
Differential aspects of church and Sunday school attendance reported by farm families in three Iowa counties.

ELECTRICAL ENGINEERING

Chopra, Anand Kumar
Dielectric fields in bundle conductors.
Foecke, Harold Anthony
Theory of a current-source.
Fuller, William Dale
Graphical analysis of a gas-triode relaxation oscillator.
Martin, David Francis
Stabilization of variable-frequency oscillator by transient feedback.
Nolte, Roger Emerson
Analysis of several phase-inverter circuits.
Robison, Wendall Cloyd
A method of calculating illumination from a glass block fenestration.
Schafer, Robert Henry
A continuously-variable phase-shifter at 10,000 cycles.
White, Richard Edward
An electrical analogue for process control.
Von Tersch, Lawrence Wayne
Factors affecting the operation of link-coupled circuits.

FOOD TECHNOLOGY

Burke, Martin Victor
A method for determining the incidence of putrefactive anaerobic spores in comminuted meat products.

Carden, Jean Boyer, Jr.
Effect of source material, processing methods, and storage conditions on the vitamin A potency of storage forms of milkfat.

FOODS AND NUTRITION

Barbour, Helen Frances
Nutritional status of Iowa children. I. Number of erythrocytes, concentration of hemoglobin, and relative red cell volume as indices of evaluation.

Kuehl, Suzanne M.
Utilization of nitrogen in the animal organism. IV. With amino acids patterned after those present in lactalbumin serving as the source of nitrogen.

McMahon, Alma Pauline
Nutritional status and dietary requirements of older women. I. Caloric intakes of 960 adult women in relation to their daily activities.

GENERAL ENGINEERING

Moehl, Richard Charles
Computation of mortality dispersion curves from incomplete data by the least Chi-square method.

Tollenaere, Lawrence R.
Rate of return of public utilities as affected by the depreciation reserve and choice of rate base.

GEOLOGY

Lawson, Ralph Willard
Lithology of the Legrand beds.

Ruhe, Robert Victory
The geology of Shelby County.

HOME MANAGEMENT

Eastvold, Helen Lucille
Finance management of a selected group of Iowa State College graduates.

Engebretson, Carol Lucille
Consumer goods produced and sold as a result of United States direct investments in Latin America and their significance in respect to standards of living in those countries.

Langley, Lorna White
Awareness of certain farm women in the Piedmont area of North Carolina to work conveniences in kitchens and laundries.
Taylor, Mrs. Vera Cook
Contemporary family practices denoting democratic living.
Young, Nina Deloris Harvey
Managerial experiences provided in high school foods classes.

HORTICULTURE

Foskett, Richard Lloyd
Relation of dry matter content to storage quality in some onion varieties and hybrids.
Wright, Johnie A.
Effects of four methods of irrigation on greenhouse rose production.

HOUSEHOLD EQUIPMENT

DeAtley, Margaret Lee
Weight losses and palatability of beef muscles cooked in a conventional saucepan and in a pressure cooker.
Hirschbeck, Virginia Ellen
Palatability of ground beef and ground pork stored in home freezers at varying temperatures.
Marron, Margaret Isabelle
Effects of temperature fluctuations in home freezers upon stored strawberries, snap beans, ground beef, and ground pork.

INSTITUTION MANAGEMENT

James, Elizabeth Louise
Cost of operating a school lunch in Iowa.
Laughlin, Sara Luella
Acceptability of foods served in an Iowa school.
Moulton, Eleanor Mears
The organization and management of the school lunch program at Ames High School, Ames, Iowa.
Seidell, Ellen Louise
Status of graduates from the Iowa State College Department of Institution Management.

LANDSCAPE ARCHITECTURE

Litton, R. Burton, Jr.
Some economic and social influences of parks upon adjoining land and property.
Narasimham, Jayanty Sree
Some post war city planning needs in India.

MATHEMATICS

Chu, Jun Tsu
Invariants of positive definite matrices under internal ransformations.

Gregory, Robert Todd
A theorem due to H. A. Schwarz and applications.

Lambert, Robert Joe
The escalator method for the solution of characteristic vector problems.

Payne, Lawrence Edward
Static wheel loads on airplane landing slabs.

MECHANICAL ENGINEERING

Bump, Thomas Richard
Flexural hysteresis of sheet phosphor bronze.

Dagefoerde, Norman Carl
Apparatus for determination of spray nozzle characteristics.

Fellinger, Robert C.
Oxygen enrichment of air in some combustion processes.

Huang, Chen-Chung
Two control problems in the soybean oil extraction plant.

Larson, Jordan Louis
Precision of measuring surface temperatures with thermocouples.

Purvis, Merton B.
Drying textiles by centrifugal action.

Sandfort, John Frederick
Thermodynamic study of the heat pump for space heating.

Schwent, Glennon Vincent
Some aerodynamic characteristics of structural angle sections.

Stanek, Floyd James
Analysis of split rings.

PHYSICS

Ehret, Dorris Maxine
Photoconductivity of cadmium sulfide.

Heidel, Robert Henry
Direct photoelectric quantitative spectrographic analysis.

POULTRY HUSBANDRY

Fagan, Harrison Brimmer
Hereditary and environmental factors influencing chick weight at eight weeks.

Kornfeld, Walter
Effects of environmental temperature and of thyroxine injection upon hens and their eggs.

PSYCHOLOGY

Braun, Richard Roy
Employee attitudes in a midwestern manufacturing company.
Hall, Howard Brereton
The effect of number of items presented upon relative retention in a five-minute newscast.
Hannum, Thomas Edward
Differential responses of veterinarians to the Strong vocational interest blank for men.
Trites, David Keightley
Correlations of item responses on the A.C.E. phychological examination with first quarter grades in engineering courses.

STATISTICAL LABORATORY

Rau, Ajjampur Ananthapadmanabha
A statistical examination of some experiments on coffee in India.
Wright, Robert Wayne
Optimum allocation of advertising expenditure among magazines.

TECHNICAL JOURNALISM

Hayes, Alva A.
The effectiveness of publicity in promoting use of certified seed.
Jibrin, Said Tu'mi
Adaptation of the American methods of communication to the needs of extension work in Syria.
Lam, Gwendoly Lenore
Difficulties in writing newspaper articles encountered by prospective homemaking teachers.

TEXTILES AND CLOTHING

Jarrett, Corrie Johnson
Practices in purchasing certain textiles and clothing of home economics students in four Negro colleges in Arkansas.
Knight, Esther Elizabeth
Wool fiber research in the United States.
Lewis, Harriet Werner
Effect of different pre-ironing treatments on the dimensional stability of certain rayon slip fabrics.
Scholtes, Mary Cleta
Selection of a test battery for the prediction of college clothing construction achievement.

THEORETICAL AND APPLIED MECHANICS

Albachten, Hubert Thomas
Torsional failure of axially loaded columns having cross sections containing no axis of symmetry.

Bowden, Roger Gerard
Distribution of stress in a rectangular steel beam under impact loading.

Godfrey, Richard G.
Stability of doubly eccentrically loaded slender columns of rectangular cross section.

VETERINARY PHYSIOLOGY

Dale, Homer Eldon
The concentration of calcium and inorganic phosphorus in the blood plasma of swine during gestation and time of parturition.

VOCATIONAL EDUCATION

Beckley, Jesse Fay
Predicting success in engineering drawing at Iowa State College from senior high school industrial education experience.

Brandt, Frank Erwin
Recordings as audio-aids for improving vocal delivery in public speaking.

Bridges, Charles Edwin
Trends in industrial arts enrollment and occupational opportunities in Vincennes, Indiana.

Buchanan, Lola Laverta
Factors related to personal problems of high school students.

Carter, John Tillman
Effectiveness of vocational agriculture as preparation for a college course in botany.

Cole, Duane Raymond
Industrial education in some colleges of Missouri.

Dean, Charles Thomas
The development of trade and industrial education in Iowa from 1917 through 1947.

Dick, Delbert Clifford
Employer interest in and attitude toward industrial arts in Maryville, Missouri.

Drake, Eldon M.
Effectiveness of vocational agriculture as preparation for a college course in dairy industry.

Garrison, Paul Isaac
Relation of high school mechanical drawing grades to achievement in engineering drawing at Iowa State College.

Hall, Clyde Woodrow
Undergraduate offerings in industrial education in Negro land-grant colleges.

Harms, Mattie Kate
An analysis of some of the factors affecting the closing of one-room rural schools in Iowa.

Harnack, Harold Henry
Daytime adult education for rural communities of Iowa.

Hawkins, Marjorie Louise
The effects of chlorination on certain physical properties of all wool and part wool fabrics.

Hunter, William Andrew
Effect of the study of chemistry in high school upon achievement in beginning chemistry in college.

John, Lewis Kephart
Opinions and activities of occupational groups of high school graduates.

Johnson, Carlton Egbert
Needed plans for the construction of homemade equipment for Iowa farms.

Jones, Vernal A.
Conservation instruction in biology courses in Iowa high schools.

Kindschy, Dwight Lewis
Course content in welding farm machinery, and tractors, for the curriculum in vocational agriculture.

Knoss, Forrest Fred
Machine shop operations in industrial arts taught in high schools of Minnesota.

Lindquist, Oiva Herbert
Relation of achievement in home economics physics to the order in which freshman chemistry and physics are taken.

Lineweaver, Gerald Artis
Characteristics to be considered in the selection and training of leaders of boys' 4-H clubs.

McKnight, Harold William
Some effects of projected audo-visual aids in senior high school industrial arts metalworking.

Miller, Allen Duane
The role of Kuder interests in prediction of course marks of freshman engineering students.

Moore, Glenn Bert
Aptitudes, interests, and personality characteristics of farm and non-farm pupils of the State Center High School.

Mortensen, Ralph Otto
A proposed reorganization of school districts in Cherokee County, Iowa.

Moseley, Gilbert A.
Job and equipment training recommendations of licensed aircraft and engine mechanics.

O'Brien, Michael
Effectiveness of vocational agriculture and industrial arts as preparation for a college course in farm mechanics.

O'Connor, William Dorsey
Consumer education taught by industrial education teachers of Iowa.

Odegaard, Alf Thorson
Use of a student managed farm in teaching a college course in farm operation.

Reynolds, Marshall L.
Provisions for teaching industrial arts in five Iowa counties.

Ross, Roland George
Implications for teaching occupational information from the opinions of Iowa teachers.

Thompson, James William
Value of the master of science program in industrial education at the Iowa State College as rated by former students.

HOME ECONOMICS EDUCATION

Adams, Zola B.
Implications for nutrition education in the food preferences of pupils in grades four through twelve of Gilbert, Iowa.

Chapin, Marjorie Evelyn
Needs related to education for personal and family living in Bondurant, Iowa.

Dudley, Pauline Glendola
Educational needs having implications for the home economics program. XX. Areas of conflict between adolescent girls and their parents.

Headlee, Mary Kathleen
The Kuder preference record as a device for differentiating among majors in the division of home economics at Iowa State College.

Hollis, Aurelia McGarrity
Educational needs having implications for the home economics program. XVIII. Expenditures of students in the business department of Blue Mountain College.

Johnson, Alice Peterscn
Home and educational background at the time of entering Iowa State College of home economics education graduates for the years 1940, 1944 and 1948.

Maceda, Delfina Salvador
Home food situations and food selection of girls enrolled in home economics at Rizal High School, Rizal, Philippines.

Mainquist, Mytle Christine
Freedom permitted adolescents when making certain personal decisions.

Martinez, Isabel Walker de
Professional attitudes and school conditions affecting home economics teachers in Puerto Rico.

Sheaffer, Mary Alice
Educational needs having implications for the home economics program. XIX. Grooming practices of junior and senior high school girls.

Stauffer, Virginia Richmond
A device to determine adjustment to peers and adults of eighth grade girls in home economics classes.

Stoflet, Dorothy Alice
Instruments for evaluation in college home economics courses: II. Test of application of principles of line in elementary costume design.

Studholme, Bertha Grace
Interest as a factor in the readability of selected material on home economics vocations.

Westbrook, May Addala
Educational needs having implications for the home economics program. XVI. Personal-social problems recognized by twelfth-grade girls.

ZOOLOGY AND ENTOMOLOGY

Barker, John Sam
Development and longevity of some plant lice as affected by nutrient deficiencies in their host plants.

Blickenstaff, Carl Curtiss
Insect parasites of *Pyrausta* species in Iowa.

Brindley, John Arthur
Bionomics of the White-pine sawfly, *Neodiprion pinetum* (Norton).

Eakins, William Wynn
Utilization of woody plants as food by Mearns cottontail, *Sylvilagus floridanus mearnsii* (Allen), in winter.

Fessler, Floyd Roscoe
A survey of fish populations in small ponds by two methods of analysis.

Fredin, Reynold Allen
Fish population estimates using the marking and recovery technique.

Fuentes del Valle, Oscar
Effects of fats and fatty acids on growth of *Dermestes vulpinus;* and influence of fish meal ether extract on oviposition.

Meng, Ching-Hua
A study of the little known sclerites in the cephalo-pharyngeal skelton of mature larvae of certain muscoil diptera.

Metz, Bertha Glancy
Methods of quieting paramecium for observation in the classroom laboratory.

Salinas, James Charles
The ecology and management of white-tailed deer, *Odocoileus virginianus* (Boddaert), in the Ledges State Park region, Boone County, Iowa.

Sieh, James Gerald
Movement and depth distribution of some common fishes in Clear Lake, Iowa.

Tate, William Harold
Growth and food habit studies of smallmouth black bass in some Iowa streams with notes on management.